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A REVISION OF THE NORTH AMERICAN SPECIES OF MEGASTIGMUS DALMAN.

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The genus Megastigmus was founded by Dalman in 1820 (Svensk. Vet.-Akad. Handl. XLI, p. 178) as a subgenus of Torymus to contain the three species: *bipunctatus* Swederus, *collaris* and *chloronotus*. *Collaris* was described by Boheman after Dalman's death in 1833 (Svensk. Vet.-Akad. Handl., p. 332). *Chloronotus* was never described but Boheman placed it under *Torymus* (*Megastigmus*) *dorsalis* Fabricius (l. c. p. 334). The type of the genus therefore cannot be *M. dorsalis* as stated by Ashmead (Chalcis-flies, p. 380, 1904) but must be *M. bipunctatus* Swederus since that is the only one of the three species cited by Dalman which was described at that time.

Megastigmus is distinguished from other Torymidæ occurring in North America by the enlarged and pigmented stigmal club and by the presence of a well developed basal vein. The posterior tibiæ have two well developed apical spurs as in other Torymidæ; Ashmead's table to the subfamilies (Chalcis-flies, p. 236, 1904) is in error on this point, and this mistake has been copied by Schmiedeknecht in Genera Insectorum, fasc. 57, p. 118, 1909. The mandibles have three teeth. The scutellum has a fine cross furrow as in *Syntomaspis*. The ovipositor, except in two species, is longer than the abdomen, slender and gently curved upward. The coloration in the American forms is never metallic; usually yellowish brown or opaque blackish.

As far as known the larvæ of all our species live in the seeds of plants.

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M. flavipes Ash. (1886) was described from males only.

Megastigmus brevicaudis Ratzeburg.

Megastigmus brevicaudis Ratzeburg. Ichneum. Forstinsect., III, p. 225. 1852.
Megastigmus brevicaudis Rodzianko. Comment. Torym., pp. 608–611. 1908.
Megastigmus brevicaudis Crosby. Cornell Exp. Sta. Bull., 265, pp. 375–377, Figs. 77–79. 1909.
Megastigmus brevicaudis Rohwer. U. S. Bur. Ent., Tech. Bull. 20, pt. VI, p. 159. 1913.

Female.—Length, 2.4 mm.; abdomen, 1 mm.; ovipositor, .7 mm.

Face, cheeks and a partial ring around eye yellow. Vertex and occiput very dark brown, nearly black. Vertex finely transversely rugulose.

Prothorax yellowish, indistinctly marked with dusky on the sides. Rest of the thorax nearly black with a dull yellowish tinge showing through on the scapulæ and scutellum. Antennæ brownish yellow, scape and pedicel black above and yellow beneath. Anterior coxæ yellow; middle and hind coxæ brownish; rest of legs light yellowish. Wings hyaline; stigmal club not surrounded by a clouded area.

Abdomen brownish on the sides, nearly black above. Ovipositor short, dark brown.

Described from 1 ♀, Ratzeburg's type. I have three females reared by W. N. Rodzianko from the seeds of *Sorbus aucuparia* at Poltawa, Russia, which agree very closely with the type.

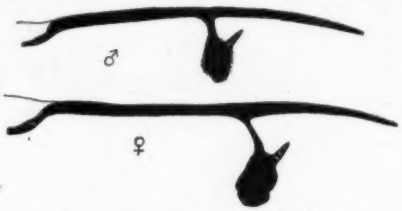


Fig. 1. *Megastigmus brevicaudis*.

Through the kindness of Mr. A. G. Hammar I received some Sorbus berries from Sweden from which 5 females were reared. In these specimens the head is black with the face dark honey-yellow. Prothorax honey-yellow, rest of thorax black. Antennæ very much darker than in the type. Abdomen black with brownish bars on the sides. Rodzianko states that he has never been able to rear the male.

I have reared this species abundantly from the seeds of Sorbus in New York State. The American specimens are slightly smaller than those from Europe and vary greatly in color, but I have been unable to find any constant character by which they may be separated. The darker individuals are very close to the typical form. A large proportion of the specimens are of uniform brownish yellow. The legs are light yellow and the antennæ and ovipositor are brownish. Between these and the typical form all gradations occur.

Male.—Length, 1.7 to 2.1 mm.; abdomen, .7 to .8 mm. All the males reared are much darker than the females. The face and cheeks are yellow; the legs dull yellowish and the antennæ more yellowish than in female. Head and thorax black except a small spot on each side between the ocelli and the eyes and an area on the lateral aspect of the prothorax, which are brownish yellow. Stigmal club surrounded by a very narrow clouded area.

Abdomen compressed, seen from the side, elongate triangular, rounded behind, brown-black above and yellowish brown beneath and at apex.

The larva is white, and its mandibles have four teeth on the inner margin.

In addition to rearing the adult insect at Ithaca, infested berries of the Mountain Ash have been found at Weedsport, Jamesville and Wayland, N. Y.

In the National Museum collection is a female specimen from Mt. Washington bearing Ashmead's manuscript name *Megastigmus slossonæ* which agrees exactly with the lighter specimens reared from Sorbus seeds from New York State. In the National Museum there is also a very dark ♀ from Oswego, N. Y., 1 July, 1897.

As suggested by Mayr. (Verh. zool.-bot. Ges. Wien, XXIV, p. 139. 1874) this species may be the same as *M. bipunctatus* Boheman.

Megastigmus physocarpi n. sp.

Female.—Length, 1.8 mm.; abdomen, .8 mm.; ovipositor, .8 mm.

Head and prothorax yellow, rest of thorax and abdomen brownish yellow, the latter much darker. Head and prothorax delicately transversely rugulose; mesothorax with a more pronounced sculpture; propodeum closely but distinctly reticulate, a distinct median carina present. A brownish line connects the ocelli.

Scape yellow; pedicel dusky above, yellow beneath, rest of antennæ dusky. Legs including coxæ light yellow. Wings hyaline. The stigmal club is narrow and elongate; not surrounded by a clouded area.

Most of the females agree with this description but there are three specimens in which the ovipositor is not over half the length of the abdomen. In these specimens the prothorax has a median black stripe narrower behind and the rest of the thoracic dorsum is black except the scapulæ and the posterior part of the propodeum.

Male.—Length, 1.6–1.9 mm.; abdomen, .7 mm.

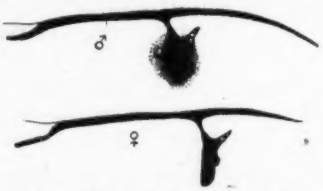


Fig. 2. *Megastigmus physocarpi.*

Similar to the female in color except the abdomen is more or less dark brown above, the antennæ are paler and the brown line connecting the ocelli is lacking. Stigmal club surrounded by a dark, nearly circular clouded area.

There are three males marked with black like the females with the short ovipositor. The abdomen is nearly black above except at tip.

Described from 15 females and 6 males from Allentown, Mo., October, 1893, and 1 male from Kirkwood, Mo., 1 July, 1895. All reared from *Physocarpus opulifolius*, probably from the seeds.

Megastigmus nigrovariegatus Ashmead.

Megastigmus nigrovariegatus Ashmead. Bull. Colorado Biol. Association, I, p. 26. 1890.

Megastigmus nigrovariegatus Cockerell. Bull. 15, Ariz. Exp. Sta., p. 69, 1895.

Megastigmus aculeatus Crosby. (in part.) Cornell Agr. Exp. Sta., Bull. 265, pp. 377–379. Figs. 82, 83, 1909.

Female.—Length, 3.4 mm.; abdomen, 1.6 mm.; ovipositor, 2.5 mm.

Vertex, antennal grooves and a spot above clypeus dark brown; face and anterior and dorsal eye margin dull brownish yellow; cheeks, posterior eye margin and occiput shining brownish.

Prothorax bright yellow posteriorly and on the sides, brownish in front on the lateral angles and just above the front coxæ. Mesonotum

brownish yellow, dark brown in front. Mesopleuræ brown. Postscutellum yellow in the middle, brown on the sides; scutellum brown in front of the furrow, yellow behind. Propodeum brown, finely reticulate punctate, with a pair of strongly curved carinæ most distinct posteriorly marking off a nearly circular central area.

Scape and pedicel yellow beneath, rest of antennæ dark brownish. Legs pale yellow; posterior coxæ at base brownish; posterior femora slightly tinged with brownish. Wings hyaline; stigmal club surrounded by a distinct oval cloud.

Abdomen brownish above, sides brownish yellow, indistinctly marked with darker brownish. Ovipositor black.

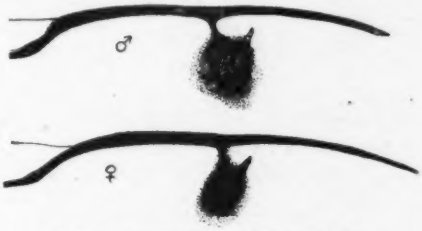


Fig. 3. *Megastigmus nigrovariegatus.*

Described from one ♀, Vancouver Island, a paratype.

In some specimens the yellowish band around the eye is complete. Sometimes the brownish area above the clypeus is lacking and the posterior femora are entirely yellow.

Male.—Length 2.8-3mm.; abdomen .9-1.4mm. (Measurements taken from alcoholic specimens). The males vary greatly in size and color. The lighter males resemble the females closely in color. Sometimes the head is all yellow except the upper half of the occiput, in others it is black except the face and portions of the ring around the eye. In some the thorax is as light as in a female, while in others it is nearly black except an irregular area on the disk and two greenish yellow spots near the posterior margin of the pronotum. In most of the males the propodeum is dark brown to black, but in the lightest specimens it is yellow. In the darkest specimens the abdomen is nearly black except the yellow tip. In the light specimens the legs are yellow, in the dark ones they are more or less brownish on the femora and tibiæ. Stigmal club much larger and darker than in female and surrounded by a clouded area.

In the National Museum collection in addition to the paratype and 4 ♀ ♀ from Vancouver Island are the following specimens belonging apparently to this species. 1 ♀, Algonquin, Ill., June 27, 1894. Labeled "Type, *Megastigmus illinoensis* Ash." 3 ♀, Jamaica Plain, Mass. (J. G. Jack). 1 ♀, Natrona, Pa.

1 ♀, Pullman, Wash., 30, June, 1898 (C. V. Piper) "Reared from *Clisiocampa plumalis.*" This specimen is imperfect, having lost the abdomen and may not belong here.

Cockerell captured specimens of this species on rose hips in Arizona and suggested that they may possibly breed in them. I have reared this species abundantly from rose seeds from Ithaca, White Church, and Wellsville, N. Y., Waukegan, Ill., Durham, N. H. (Charles Spooner), Boston, Mass. (Ralph Curtis), Provo, Utah (R. V. Chamberlin), and Newark, Del. (C. O. Houghton). Professor J. G. Sanders sent me specimens reared from the seeds of *Rosa rugosa*, at Madison, Wis. Mr. Nathan Banks has sent me 9 specimens reared from rose hips at Falls Church, Va.

Some of these localities are listed under *M. aculeatus* in Cornell Exp. Sta. Bull. 265 because at that time I had not separated these two species. It is probable that *nigrovariegatus* is the native American species infesting rose seeds and that *aculeatus* has been introduced recently, since I have reared it from material collected at Ithaca only.

Megastigmus pinus Parfitt.

Megastigmus pinus Parfitt. Zoologist, pp. 5543, 5545, 5629. 1857.
Megastigmus pinus Rohwer. U. S. Bur. Ent., Tech. Bull. 20, pt. VI, p. 160. 1913.

Female.—Length, 4 to 5 mm.; abdomen, 2.3 mm.; ovipositor, 5 to 5.5 mm.

Vertex and occiput black; face, cheeks and a ring around eye yellow, the latter broadly interrupted by the black of the vertex which attains the eye-margin below the level of the front ocellus; antennal furrows black; below the insertion of the antennæ there is a circular area cut off from the rest of the face by two or four brownish spots, very variable in shape and distinctness; hairs on the face light colored, above the base of antennæ, brown. Vertex and front transversely rugulose; cheeks and lower part of occiput smooth; face with lines radiating from the clypeus.

Prothorax black, with the sides and a large posterior dorsal band greenish yellow; this band is usually biconvex in front. Mesothorax black with an oblong reddish orange area covering the posterior half of the middle lobe, the inner angles of the scapulæ and axillæ and all of the scutellum. In some small specimens this orange area is obscured by blackish in the center. Sculpture of mesonotum distinctly transversely rugulose. Scutellum with the transverse stria distinct. Pleuræ black, scapulæ have a large greenish yellow spot in front of tegulæ. Postscutellum black with a transverse median band of light yellow. Propodeum black, irregularly rugose with a delicate median carina.

Scape yellow below, black above; pedicel black above, paler at tip beneath; rest of antennæ brownish. Front coxæ yellow; middle coxæ yellow in front, black behind; hind coxæ black; legs yellowish, the middle and hind pairs successively darker; a brownish stripe on outside of posterior femora. Spines on posterior tibiæ white and small. Wings hyaline, no cloud surrounding stigmal club.

Abdomen strongly compressed. Segments 2, 3 and 4 brownish black above, polished; rest of abdomen yellow to yellowish brown with a row of large brownish black spots on each side; segment 8 and ventral keel brownish black. Ovipositor brown and strongly curved.

Male.—Length, 3 mm.; abdomen, 1.3 to 1.9 mm.

Head marked as in female but there are no brownish spots below the insertion of the antennæ. Thorax black; median orange-red area lacking; prothorax has the sides yellow and there are two widely separated transverse dull yellowish spots near the posterior margin; usually the outer angle of the scapulæ has a yellow spot in front of the tegulæ. Stigmal club surrounded by a very narrow clouded area.

Abdomen shorter than in the female, somewhat compressed, seen from above distinctly clavate, yellow beneath, black above, tip orange yellow.

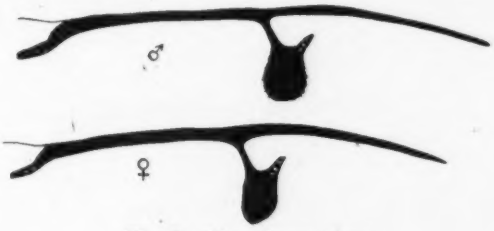


Fig. 4. *Megastigmus pinus.*

This species was first described by Parfitt from females only reared from seeds of *Picea bracteata*, *Pinus Abies nobilis*, and a new species of *Thuja* from California. In a later article he described the male reared from another lot of seeds. Mr. Charles O. Waterhouse of the British Museum has very kindly sent me four specimens which he had carefully compared with Parfitt's types. He also sent me three male specimens of *M. spermotrophus* which he had found to agree with the types from which Parfitt drew his description of the male of *M. pinus*. Ashmead seems to have been misled by this description of the male of *M. spermotrophus* as the male of *pinus* when he states (Chalcis-flies, p. 244) that the two species are identical.

2 ♀, 2 ♂ C. O. Waterhouse (Col. British Museum); 16 ♀, 10 ♂ reared from cones of *Abies nobilis*, Astoria, Oregon. No. 5818, Nat. Mus. The following specimens were reared by

Mr. Herman Borries, of Copenhagen, from seeds from the Western United States: 3 ♀ reared from *Abies magnifica* and *concolor*; 1 ♀, 1♂ from A. *grandis*; 2 ♀, 1 ♂ from *A. amabilis*. I have also examined the following specimens from the U. S. Bureau of Entomology through the kindness of Mr. S. A. Rohwer. 15 ♀ and 12 ♂ reared from the seeds of *Abies magnifica* from Tahoe, Calif. National Forest. 2 ♀ and 6 ♂ reared from the seeds of *Abies concolor* from Sierra, Calif. National Forest, 30 May, 1912, collected by J. M. Miller. The specimens from *A. concolor* are somewhat smaller and generally darker in coloration.

The female reared from *A. grandis* by Borries may represent a distinct species but it is impossible to decide from such scanty material. The yellow area on the prothorax is very large, covering nearly the whole dorsal aspect and on the vertex there is on each side a branch of the circumorbital yellow band which curves around behind the lateral ocellus. The male is not in good condition for study.

Megastigmus tsugæ n. sp.

Female.—Length, 2.5 mm.; abdomen, 1.1 mm.; ovipositor, 1.8 mm.

Face and cheeks yellow; occiput, vertex and front black; the upper posterior orbits and a spot at the upper angle of the eye yellowish brown. Antennal grooves black. Prothorax black with two angular, widely separated dorsal spots and the anterior half of the lateral part yellow. Rest of the thorax shining black. Mesonotum and scutellum finely shingled.

Fig. 5. *Megastigmus tsugæ.*

Scape and pedicel yellow beneath. Anterior coxæ yellow, middle coxæ brownish yellow, posterior coxæ black; rest of legs yellowish; base of femora and band at middle of tibiæ on middle and posterior legs brownish. Wings hyaline; stigmal club not surrounded by a clouded area. Abdomen black with five more or less distinct yellow bands at the sides; tip yellowish. Ovipositor black.

Described from 2 females reared by Mr. Herman Borries from seeds of *Tsuga Mertensiana hookeriana* from the Western United States. Type in the U. S. National Museum.

Megastigmus lasiocarpæ n. sp.

Female.—Length, 3.7 mm.; abdomen, 1.5 mm.; ovipositor, 3. mm. Thorax and abdomen black. Face and partial ring around eye yellow, a pair of large triangular brownish spots on the face; rest of head black. An elongate light yellow spot on the side of the prothorax. Transverse lateral spots on the sides of abdomen yellow. Head finely rugulose with the lines radiating from the mouth and ocelli. Thorax transversely finely rugulose and shingled.

Antennæ brownish black, scape and pedicel yellow beneath. Legs brownish, posterior femora black except at tip. Anterior coxæ yellow, black at base, the other coxæ black. Wings hyaline; stigmal club not surrounded by a clouded area.

Fig. 6. *Megastigmus lasiocarpæ.*

Male.—Length, 2.4 mm.; abdomen, 1 mm.

Vertex, upper part of occiput and front half way to base of antennæ, black; face, cheeks, lower occiput and a narrow spot along upper eye-margin, yellow. Whole dorsal aspect of thorax black; the yellow spot on side of prothorax is larger than in female. Abdomen black.

Antennæ brownish, scape yellow in front, pedicel nearly black above. Front coxæ yellow, middle coxæ yellow, blackish at base, hind coxæ black. Legs yellowish, suffused with brownish distally; posterior femora brownish on outer surface. Stigmal club darker than in female and more nearly circular.

Described from 2 ♀ 1 ♂ reared from seeds of *Abies lasiocarpa* kindly sent me by O. S. Mackelfresh, from Rye, Colorado, 5 June, 1909.

Megastigmus spermotrophus Wachtl.

Megastigmus spermotrophus Wachtl. Wien. Ent. Zeit., XII, p. 24. 1893.
Megastigmus pinus Parfitt. Zoologist, XV, p. 5731. 1857 (Male only).
Megastigmus spermotrophus MacDougall. Trans. Roy. Arbor. Soc., XIX, pp. 52–65. 1906. Figure and account of habits.
Megastigmus spermotrophus Crosby. Cornell Exp. Sta. Bull. 265. pp. 379–380. Figs. 85–89. 1909.
Megastigmus spermotrophus Rohwer. U. S. Bur. Ent., Tech. Bull. 20, pt. VI, p. 160. 1913.

Female.—Length, 3–3.5 mm.; abdomen, 1.8 mm.; ovipositor, 1.6 mm.

General color a yellowish brown. Face and cheeks lighter than the vertex. Face with fine lines radiating from the clypeus; vertex and thorax finely transversely rugulose. Head and thorax clothed with stiff black hairs arising from black tubercles. Median area on postscutellum, greenish yellow. Propodeum with a distinct median carina.

Antennæ brownish, scape yellow beneath, pedicel nearly black above. Legs including the coxæ paler than the thorax. The posterior coxæ clothed with stiff light-colored hairs, arising from black tubercles. Wings hyaline; stigmal club not surrounded by a cloud; stigmal vein as long as the width of club.

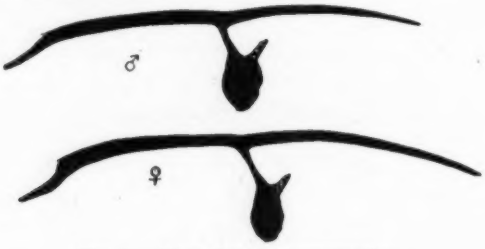


Fig. 7. *Megastigmus spermotrophus.*

Male.—Length, 2.9–3.3 mm.; abdomen, 1.2–1.7 mm. (Measurements taken from alcoholic specimens.)

Head, thorax and legs a clearer yellow than in the female. On the front of the pronotum a dark brown spot is sometimes present which is sometimes divided into two. Sometimes the front of the mesothorax is black and shows through the posterior edge of the prothorax. Median and anterior portion of the propodeum black; sides and posterior margin yellow. Stigmal club darker than in female, not surrounded by a clouded area.

Abdomen brownish yellow, black at base above.

Described from numerous specimens of both sexes reared from seeds of the Douglas Fir sent me by Mr. John Crozier, of Aberdeenshire, Scotland.

The egg as obtained by dissection of the female is white, smooth and spindleshaped with a very long pedicel at the anterior end and the vestige of one at the opposite end. Length of body of egg, .36 mm.; tail like process, .9 to 1.2 mm.

The full grown larva is yellowish white with brownish mouthparts; its length varies from 2.5 to 3.5 millimeters. The surface is smooth without apparent sculpture and the hairs are very sparse and microscopic in size. The inner margin of the mandibles is provided with three sharp teeth.

The pupa is yellowish white and in the female has the ovipositor curved over the back and reaching to about the middle of the thorax. Length of female pupa, 3 mm.; of male, 2.5 mm.

While originally a native of the Western United States it has been introduced into Europe and has there become a serious pest. The male of this species was described by Parfitt in 1857 as the male of *M. pinus*. Mr. Charles O. Waterhouse of the British Museum has kindly sent me three males of this species which he compared with Parfitt's types. Safro (Jour. Ec. Ent., VI, p. 283. 1913.) records rearing this species from seed of Douglas Fir in Washington.

The species listed under B in Riley's article (Proc. Ent. Soc. of Wash, II, p. 360) also belong to this species. They were reared from seeds of *Pseudotsuga douglassi*, [*taxifolia*], *Abies magnifica*, *A. grandis*, *A. amabilis* and *A. concolor*.

Through the kindness of Mr. S. A. Rohwer I have been able to examine specimens from the U. S. Bureau of Entomology as follows: 4 ♀ 4 ♂ reared from seed of *Pseudotsuga taxifolia* from Yreka, Calif., April and May. 3 ♀ 2 ♂ reared from seed of *Abies magnifica* from Tahoe, Calif. National Forest, June, 1912; 1 ♀ 1 ♂ from seeds of *Abies concolor*, from Sierra, Calif. National Forest (J. M. Miller, Collector).

Megastigmus aculeatus Swederus.

Pteromalus aculeatus Swederus. Vetensk. Akad. nya Handl., XVI, p. 221. 1795.
Torymus collaris Boheman. Vetensk. Akad. nya Handl., LIV, p. 332. 1833.
Megastigmus transversus Walker. Ent. Mag. I, p. 117. 1833.
Torymus punctum Fœrster. Beitr. Monogr. Pteromal, p. 29. 1841.
Megastigmus vexillum Ratzeburg. Ichn. d. Forstinsect. II, p. 182. 1848.
Megastigmus transversus Reinhard. Berl. Ent. Zeitschr., I, p. 76. 1857.
Megastigmus flavus Fœrster. Verh. Nat. Ver. preuss. Rheinl. XVI, p. 109. 1859.
Megastigmus collaris Mayr. Verh. zool.-bot. Ges. Wien. XXIV, p. 137. 1874.
Megastigmus aculeatus Thomson. Hymen. Scand. IV, p. 1. 1875.
Megastigmus cynorrhodi Perris. Ann. Soc. Ent. Fr., 1876, p. 222.
Megastigmus aculeatus Cameron. Trans. Ent. Soc. Lond., 1879, p. 118.
Megastigmus collaris Wachtl. Wien. Ent. Zeit., III, pp. 38, 39. 1884.
Megastigmus aculeatus Crosby. (In part). Cornell Exp. Sta., Bull. 265, pp. 377–379. 1909.

Female.—Length, 3 mm.; abdomen, 1.5 mm.; ovipositor, 4 mm.

General color brownish yellow. Face and cheeks yellow; vertex brownish yellow; occiput with a narrow band of black above the opening. Pronotum pale yellow behind, mesonotum black in front where it shows through the thin posterior edge of the pronotum, the anterior half reddish yellow; axillæ black except the inner angle; anterior half of the propodeum black or dark brown. Median carina of propodeum not pronounced. Median part of the postscutellum greenish yellow.

Antennæ very dark brown, nearly black, scape beneath yellow. Legs yellow, wings hyaline. Stigmal club oval, not surrounded by a cloud, the stigmal vein shorter than the width of club.

Abdomen brownish yellow on the sides, dark brown above banded with yellow. Ovipositor longer than body, black and curved.

Fig. 8. *Megastigmus aculeatus.*

Described from numerous specimens reared from rose seeds at Ithaca, N. Y. In Bull. 265, Cornell Exp. Sta. I have confused this species with *M. nigrovariegatus*. All the other localities there given refer to that species. Figures 82 and 83 are also of *nigrovariegatus*. In the collection of the U. S. National Museum there is a series of specimens reared from rose seeds imported from Peking, China. I have also reared several specimens from rose hips from Heilbronn, Germany, procured for me by Mr. Carl Ilg from his friend, Mr. Gustav Wieland.

Megastigmus flavipes Ashmead.

Megastigmus flavipes Ashmead. Trans. Am. Ent. Soc. XIII, p. 128. 1886.

"Male.—Length, .12 inch. Head and thorax bright golden green, face finely reticulately strigose; thorax irregularly, transversely, coarsely strigose; antennæ clavate, scape and flagellum beneath yellow, flagellum above brown-black; the collar is rather short; the scutellum at tip is divided by a transverse suture and with a raised rim at border posteriorly; abdomen ovate, black; legs waxy yellow; wings hyaline, veins pale, excepting the stigmal vein, which is brown, and ends in a circular stigma.

"Described from one specimen taken in August."

In the United States National Museum collection there is the pin on which the type was originally tag-mounted. Only the hind legs and one front wing remain. The stigmal club is large, very dark colored and appears to be surrounded by a narrow clearly defined cloud.

In 1888 (Bull. 3, Kansas Agricultural Experiment Station, p. III) Ashmead described another species under the same name, *Megastigmus flavipes*. Through the kindness of Professors T. J. Headlee and G. A.

Dean, I have been able to examine the type of this species. It is a male *Torymus*. As the original description is rather brief I will publish a more complete description elsewhere.

Megastigmus albifrons Walker.

Megastigmus albifrons Walker. Trans. Ent. Soc. London, 1869. p. 314.

Female.—Length, 5 mm.; abdomen, 2 mm.; ovipositor, 4 mm. (abdomen contracted in drying).

Head yellowish white, with many black punctures from which arise black hairs; on the middle of the face the hairs are yellowish; an area including the ocelli and extending almost to the eye margin, black.

Prothorax dull yellowish, the dorsum marked with a wedge-shaped black spot from the front corner of which a black line curves around along the lateral margin and almost reaches the posterior edge of the segment. Central lobe of the mesonotum black except along the lateral edge; lateral lobes brownish, blackish in the center. Scutellum black except along side and at apex where it is yellowish brown. Axillæ black in the center, surrounded by yellowish brown. Post scutellum yellowish white in the center, black on the sides. Propodeum black, yellowish white at the sides. Pleuræ yellowish white.

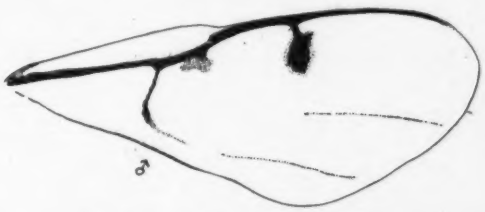


Fig. 9. *Megastigmus albifrons.*

Anntenæ brownish, scape yellowish at base and below. Legs yellowish brown; tarsi blackish at tip. Front wings hyaline with a distinct brownish spot adjoining the hind margin of the submarginal vein beyond the junction with the basal vein. Basal vein unusually distinct. Stigmal club surrounded by an indistinct clouded area scarcely discernible when viewed with a hand lens.

Abdomen shining black above, spotted with dull-yellowish on the sides and below. Ovipositor black, the extreme tip yellowish.

Male.—Length, 6 mm.; abdomen, 2.5 mm.

Head similar to female. Thorax dull yellowish marked with a black median line, enlarged in front on the prothorax, narrower on the median lobe of the mesothorax and again enlarged on the scutellum. The lateral black marking on the prothorax of the female is here replaced with brownish.

Mesonotum distinctly brownish. Axillæ black along the anterior margin. Legs more distinctly brownish than in the female. In the fore wing the brownish spot adjoining the submedian vein is more distinct than in the female, and the stigmal club is surrounded with a distinct clouded area.

Abdomen shining black above, brownish yellow below.

Described from 1 ♀ and 1 ♂. Placerville, Cal., 8 Feb., 1913. Reared by J. M. Miller from the seeds of *Pinus ponderosa*. Received through the kindness of S. A. Rohwer.

Megastigmus canadensis Ashmead (Trans. Am. Ent. Soc., XIV, p. 186. 1887).

The type in the United States National Museum is a male Pteromalid.

Through the kindness of Dr. Henry Skinner, I have been permitted to examine specimens of the two following species in the collection of the American Entomological Society.

M. cecidomyiæ Ashmead (*l. c.* XIV, p. 185. 1887).

Two specimens, male and female, both tag-mounted on the same pin, "E. Fla., Ashmead" and labeled with the name in Ashmead's hand-writing. They belong to the genus *Lochites*.

M. ficigeræ Ashmead (*l. c.* IV, p. 185. 1887). One male. The head is glued to the card point separately. The antennæ are lacking. It is apparently an Encyrtid. "E. Fla. Ashmead." Name in Ashmead's handwriting.

These specimens were probably the ones from which Ashmead drew up his description of the species.

In 1892 C. V. Riley received a series of specimens of *Megastigmus* reared from the seeds of various conifers by Mr. Herman Borries, of Copenhagen, Denmark. He published (Proc. Ent. Soc. Wash. II, pp. 359-363) an article on the habits of this genus in which he gave a list of the specimens reared by Mr. Borries and data in regard to the host plants. I have examined these specimens in the National Museum Collection and for convenience quote the list and indicate the species to which each lot belongs.

"A. Very handsome species marked with black, red, and yellow. II and V from *Abies magnifica* and *concolor*, somewhat smaller and paler; III, from *A. grandis*, distinctly smaller, much paler; IV, from *A. amabilis*, larger and darker. ♂ and ♀ of all varieties. [*M. pinus* Parfitt.]

"B. Entirely yellow species, also variable; perhaps two species mixed. I, from *Pseudotsuga douglassi* [*taxifolia*] ♂ and ♀; II, from *Abies magnifica;* III, from *A. grandis;* IV, from *A. amabilis;* V, from *A. concolor.* [*M. spermatrophus* Wachtl.]

"C. Very small, dark species, very similar to small specimens of the European *M. strobilobius.* From *Tsuga* [*mertensiana*] *hookeriana.* 2 ♀ [*M. tsugæ* n. sp.]

"D. Entirely black species from Japan. From *Abies mariesi* 2 ♀. *[*M. borriesi* n. sp.]

"E. *M. strobilobius* Ratzeb. from Denmark. 5 ♀."

Fig. 10. *Megastigmus borriesi.*

**Megastigmus borriesi* n. sp.

Female—Length, about 3.3 mm.

Head, thorax and abdomen dark brown, nearly black; yellowish around mouth. Antennæ of the type still in pupal sheaths. Scape brownish lighter beneath. Legs brownish yellow, the posterior femora darker. Coxæ dark brown like the thorax. Wings hyaline, the stigmal club without a surrounding cloud. Ovipositor as long as abdomen.

Described from two females in rather poor condition. Reared by Mr. Herman Borries from seeds of *Abies mariesi* from Japan.

TABLE OF HOSTS.

M. aculeatus Swederus—Rose seeds.
M. albifrons Walker—Seeds of *Pinus ponderosa.*
M. brevicaudis Ratzeburg—Seeds of Sorbus.
M. borriesi Crosby—Seeds of *Abies mariesi* from Japan.
M. flavipes Ashmead—Unknown.
M. lasiocarpæ Crosby—Seeds of *Abies lasiocarpa.*
M. nigrovariegatus Ashmead—Rose seeds.
M. physiocarpi Crosby—Seed capsules of *Physocarpus opulifolius.*
M. pinus Parfitt—Seeds of "*Picea bracteata,*" *Abies nobilis, Abies magnifica, Abies concolor, Abies grandis, Abies amabilis.*
M. spermotrophus Wachtl—Seeds of *Pseudotsuga taxifolia, Abies magnifica, Abies grandis, Abies amabilis, Abies concolor.*
M. tsugæ Crosby—Seeds of *Tsuga mertensiana hookeriana.*

ACKNOWLEDGMENTS.

My indebtedness to the many persons who have aided me in the preparation of this paper by the loan of specimens and other material and in other ways is duly acknowledged in the preceding pages. My thanks are especially due to the authorities of the United States National Museum and of the Bureau of Entomology at Washington for the loan of many specimens and to Mr. C. O. Waterhouse of the British Museum for an examination of Parfitt's types.

The drawings were all made by Miss Anna C. Stryke, of Ithaca, N. Y.

THE NEUROPTEROUS GENUS PALPARES.

By Nathan Banks.

To the genus *Palpares* belongs the most magnificent of the Neuropterous insects. Their large size and contrasting markings has attracted even the collector of butterflies so that now a considerable amount of material exists in the various museums, a much more representative collection than any other group of exotic Neuroptera.

Having recently seen many of the collections and having a number of species in my own, I have endeavored to prepare a table with such notes as may be useful in identifying the various species.

Africa is the home of the genus, two species occur in Southern Europe, several in India and Persia, and one has been taken in the Madeira Islands. Elsewhere there are none, nor even a closely allied genus.

Several attempts have been made to divide the genus. Hagen made *Stenares* for those species in which the costal cells were crossed. This character is often variable in development, in many Myrmeleonidae, but in *Palpares* it appears to be more constant; the species of *Stenares* always have two rows of cells for most of the costal length, while in the true *Palpares* it is rare to find even one cell crossed. *Panexis* was created by Hagen for certain small, broad-winged species, the type of which has a thickened subcosta. Until better characters are given, it is best to keep *Panexis* as only a subgenus.

McLachlan proposed to divide both *Palpares* and *Stenares* according to whether the outer margin of the wings were strongly sinuated or not. Thus *Symmathetes* is for species of *Palpares* with sinuated margin and *Crambomorphus* is for those *Stenares* with a sinuated margin. However as we know more species of *Palpares* it becomes increasingly difficult to tell whether the margin is strongly sinuated or not; thus *P. amitinus*, *P. insularis*, *P. inclemens* and *P. latipennis* all have the margin plainly sinuated, and other species show this character in a slight degree. Lately Navas has proposed various new genera, *Nosa* for *P. tigris* which has apparently two radial sectors, although in reality it has no more longitudinal veins than other *Myrmeleonidae*. *P. tigris* is so closely related by other characters to species with but one radial sector that I cannot

consider it generically different from *Palpares*. *Palparellus* was made by Navas for *P. spectrum*, but *P. ovampoanus* connects this group with the section of *P. flavofasciatus*.

Golafrus was made for *P. oneili* on account of the emargination at base of the fore wing. I suspect this character exists only in the male sex, besides *P. oneili* is otherwise related to *P. radiatus*.

If these names are to be used for subgenera, others should be created for other sections or groups. In the appended notes I have given certain facts regarding the anal venation which, although not sufficiently different to divide the genus, are fairly constant for each species. The color of the legs is valuable, and I tabulate the black and pale legged species below.

The color of the vertex and the presence of spots on thorax and on abdomen are also very useful. The point of origin of the radial sector in the fore wings is also useful; in *P. libelluloides* it is as far basad as the cubital fork, in many other species it is plainly beyond this point.

The palpi are variable in length according to the species; in *P. libelluloides* the last joint of the maxillary palpi is much longer than the space between the eyes, in *P. speciosus*, *P. moestus* etc., it is shorter.The male appendages also vary in length, but little in structure; in *P. speciosus* and allies they are very short, in *P. tigris* very long and with a basal tooth.

The markings of the wings, although variable in development, are extremely useful, especially the shape of the apical marks. It is doubtful if the character of median band across hind wing is of specific value. The size of species does not vary much, but the width of the hind wings does vary to some extent in the same species. The width of the face between the eyes is very narrow in *Palparellus* and the *flavofasciatus* group, in others wider. In the table I have placed a number of names as synonyms, based (in most cases) on my examination of the types, but I am quite certain that a still greater number should also be placed as synonyms, or at most varieties. All the species allied to *P. speciosus* are probably but forms of that species, for the marks are all on the same plan and the male genitalia the same. Likewise several species will later fall under *P. tristis* as collections are more extensive.

P. cognatus Rbr I have not seen, nor been able to place it; its habitat is unknown.

Arranged according to the color of legs they are as follows:

Legs all black, or pale on part of tarsi.
speciosus, caffer, digitatus stuhlmanni, flavofasciatus, festivus, formosus, amitinus, insularis, spectrum (and allies) *damarensis, tigroides, cataractæ, immensus, contrarius, pardaloides.*
Legs with pale on femora or tibiæ.
libelluloides, hipanus, pardus, inclemens, latipennis, nyicanus, ægrotus, tristis, tigris, obsoletus, mæstus, interioris, angustus, oneili, sparsus, radiatus, tessellatus, furfuraceus, zebratus.

The species may be arranged in the following groups:

vœltzkowi group.
Includes also *obscuripennis.*
mæstus group.
Includes *cataractæ, martini* and *contrarius.*
flavofasciatus group.
Includes also *compositus, formosus, damarensis, bifasciatus, festivus,* and *elegantulus.*
spectrum group.
Includes also *rothschildi, astutus,* and *ovampoanus.*
luteus group (*Pamexis*).
Includes also *translatus* and *contaminatus.*
speciosus group.
Includes also *digitatus, caffer, varius, stuhlmanni,* and *dubiosus.*
libelluloides group.
Includes also *papilionoides, hispanus, percheroni* and *tessellatus.*
solidus group.
Includes also *walkeri,* and *angustus.*
tigris group (*Nosa*).
Includes also *ægrotus, ornatus.*
pardus group.
Includes also *tigroides, zebratus.*
tristis group.
Includes also *interioris, obsoletus klugi, extensus, lentus, similis, pardaloides, nigrita.*
sparsus group.
Includes also *sobrinus, furfuraceus, abyssinicus, nyicanus.*
cephalotes group.
Includes also *inclemens, incommodus, latipennis, radiatus, immensus, o'neili, astarte, patiens* (*infirmus*), and *karrooanus.*
insularis group.
Includes also *amitinus.*
gigas group.
No others known.

The African species are tabulated below, after which are the Indian species.

TABLE OF AFRICAN SPECIES.

1. Hind margin of fore wings with a long emargination at base; wings narrow, streaked with dark.....*o'neili* Per.
Hind margin not emarginate near base.....2.
2. Anterior apical margin of hind wings straight or slightly concave, tip acute; large heavily marked species the outer margin of wings sinuate...*gigas* Dal.
Anterior apical margin of hind wings convex.....3.
3. Hind wings mostly black on the basal part before cubital fork as elsewhere; with only isolated pale spots.....4.
Hind wings largely pale, and pale on basal part before the cubital fork....5.

4. Wings slender, acute at tips; hind pair with a pale apical streak.....
karrooanus Per.
Wings broader, not acute; hind pair without apical streak; several isolated pale spots.....*vœltzkowi* Weele
5. Vertex dark or blackish, legs wholly black.....6.
Vertex pale, with a median dark stripe, or at least outlined by pale spots..26.
6. A large spot at or near the cubital fork in the hind wings.....16.
No spot near cubital fork in hind wings, the base being all pale.....7.
7. In hind wings the dark extends along the costa to base.....8.
In hind wings the dark does not extend to base, at most some isolated dark marks.....10.
8. Fore wings with large pale space in the middle, wings rather slender.....
ovampoanus Per.
Fore wings without a large pale space in middle.....9.
9. Both wings with pale post-stigmal bands.....*spectrum* Rbr.
These bands broken into spots.....*rothschildi* Weele
10. Fore-wings dark, with black bands; hind wings with nearly two-thirds black with small white spots; expanse over 100 millimeters.....
obscuripennis Sch.
Fore-wings yellowish or hyaline in pale areas.....11.
11. The subcosta of fore wings thickened near the stigma, wings yellow with dark bands, hind wings very broad.....*luteus* Thunb.
The subcosta of fore wings not thickened.....12.
12. Median band of hind wings does not reach up to the radius, but from middle of wing behind in form of three spots.....*contaminatus* Hag.
Median band of hind wings reaches across the wing from radius to hind margin.....13.
13. Apex of fore-wings dark with a distinct pale band before it.....14.
Apex without such marks.....15.
14. Dark bands of hind wings not connected.....*flavofasciatus* McLach.
Dark bands of hind wings connected.....*compositus* Navas.
15. Fore and hind wings with apical marks in the form of longitudinal streaks..
elegantulus Per.
These marks not in the form of streaks, but band or spots.....*festivus* Gerst.
16. Small very broad-winged species; greatest breadth of the hind wings much beyond the middle; basal band of the fore wings reaches to the hind margin.
translatus Walk.
Larger; wings more slender; greatest breadth of hind wings at middle of length or before.....17.
17. Hind wings with the stigmal band broad and in front in two parts; wings not yellowish; basal band of hind wings nearly across, or in two nearly connected spots.....*cataractæ* Per.
Hind wings with the stigmal band entire on the front margin.....18.
18. Abdomen pale yellowish red; wings yellowish brown; small species; bands of hind wings narrow, apical mark in form of two streaks..*bifasciatus* Oliv.
Abdomen pale on base, darker toward tip.....19.
19. Pronotum with yellow each side; fore wings often more or less yellowish, and the median and stigmal bands often only spots with dark borders; thorax very hairy, not showing the pale spots, male appendages very short ...21.
Pronotum with two yellowish spots on front margin (maybe connected); pale median spots on thorax visible.....20.
20. Few spots between stigmal and median bands in fore wings; apical mark in form of streaks.....*damarensis* McL.
Many spots between bands; apical mark not in form of streaks..*formosus* Bks.
21. Bands of hind wings connected together; apical mark of hind wings encloses but one pale spot.....*stuhlmanni* Kolb.
Bands of hind wings separate.....22.
22. In fore wings the small basal spots are arranged so as to leave two clear longitudinal streaks; stigmal and median bands of hind wings reach across with two or three fingers each; sides of pronotum more narrowly yellow.
digitatus Gerst.
Basal spots of fore wings not arranged to leave clear spaces; sides of pronotum broadly yellow.....23.

23. Hind wings tessellate with spots along the hind border....24.
Hind wings not tessellate with spots along the hind border...*dubiosus* Per.
24. Bands of hind wings reach across; wings rather more narrow..*speciosus* L.
Bands of hind wings do not reach across....25.
25. Spots greatly reduced in size....*varius* Nav.
Spots of moderate size....*caffer* Burm.
26. A large spot on the forking of the cubitus in the hind wing....51.
Only a small dot on this forking, but sometimes there are marks near by, above or around the forking....27.
27. Hind margin of both wings narrowly, evenly fumose all along; stigmal spot of fore wings hardly reaches the radius; bands of hind wings not reaching across the wing....28.
Hind margin of the wings with at most separated dark spots; not evenly fumose all along, always some pale spaces....30.
28. Fore wings with apparently two radial sectors arising close together; the lower of the apical spots is triangular; no band below antennæ..*tigris* Dalm.
Fore wings with but one radial sector; a black band below antennæ....29.
29. Stigmal band of hind wings concave within; lower apical mark of fore wings hardly in form of two streaks....*ornatus* Nav.
Stigmal band of hind wings not concave within, often broken; lower apical mark of fore wings in form of two parallel, slightly curved streaks....
ægrotus Gerst.
30. Fore wings with many small dark spots, and no large spots or bands....31.
Fore wings with large spots (perhaps netted) or bands....35.
31. Hind wings with all small spots....32.
Hind wings with some moderately large spots....33.
32. Longitudinal space behind the first branch of radial sector in fore wings pale, unmarked....*sparsus* McLach.
This space with spots as elsewhere....*sobrinus* Per.
33. Vertex greatly swollen; thorax with fulvous hair; spots in hind wings mostly rounded....*furfuraceus* Rbr.
Vertex not so swollen; some spots in hind wings in the form of streaks....34.
34. Longitudinal space behind the first branch of radial sector in fore wings mostly unspotted....*abyssinicus* K.
This space with spots as elsewhere; hind wings with median spots, a spot or streak beyond and apical streaks....*nyicanus* Kolbe.
35. Apical marks of hind wings in the form of longitudinal spots or streaks...36.
Apical marks not so; transverse....42.
36. A submarginal line in fore wings....39.
No such line; bands of hind wings not across....37.
37. Bands of fore wings usually small and faint; hind margin of hind wings with long curved streaks reaching towards the bands; femora not spotted...
obsoletus Gerst.
Bands of fore wings distinct; hind margin of hind wings not so plainly streaked, mostly short spots; femora spotted....38.
38. Larger, spots not broken up much; face mostly black; abdomen not striped.
tristis Hag.
Smaller, spots more broken up; the male appendages shorter; narrow band below antennæ; abdomen striped....*interioris* Kolbe.
39. Stigmal mark in the hind wings divided, not reaching across; fore wings with an apical cloud....*klugi* Kolbe.
Stigmal mark in hind wing entire; fore wings with apical streaks....40.
40. Stigmal mark of fore wings in form of a streak; stigmal band of hind wings not across....*immensus* McL.
Stigmal spot of fore wing band-like....41.
41. Stigmal and median bands of hind wings not across....*similis* Stitz
These bands reach across....*reticulatus* Stitz.
42. Median band of hind wings with a projection toward the cubital fork, or else a separated spot near by; stigmal band with upper inner projection and also one behind....43.
No such projection to median band, nor a separated spot near by....44.

43. Median band of hind wings has a projection toward the cubital fork; large species ..... *latipennis* Rbr.
Median band not with a projection, but a large spot near the cubital fork.. *inclemens* Walk.
44. Fore wings with four distinct bands; hind wings with straight bands; no dots along hind border of either wing..... *normalis* Nav.
Fore wings with but three bands; bands of hind wings not straight.....45.
45. Median and stigmal bands of hind wings connected..... *amitinus* Kolbe.
Median and stigmal bands separated.....46.
46. Median band of hind wings reaches across; bands not netted.....47.
Median band does not reach across the hind wing.....49.
47. Stigmal band of two more or less connected bands; apical mark of fore wing entire; a large costal sub-basal spot dark; outer margin of wings plainly sinuate..... *mæstus* H.
Stigmal band of but one band, perhaps with projections; no large sub-basal costal spot in fore wings.....48.
48. Apical mark of fore wings entire; inner projection of stigmal band of hind wings directed backward..... *insularis* McL.
Apical mark of fore wings divided; inner projection of stigmal band of the hind wings directed upward..... *lentus* Nav.
49. Bands netted; median band of hind wings with emargination on the inner side..... *nigrita* Nav.
Bands not netted; hind wings rather broader in the middle.....50.
50. Fore wings with many moderate-sized spots; the stigmal band very small; no other bands; from Madagascar..... *pardaloides* Weele.
Fore wings with only small dots and bands; median band of hind wings with an emargination on inner side; large spot on middle of hind margin.... *geniculatus* Nav.
51. Abdomen yellow, each segment with a broad black transverse basal band; no longitudinal stripe; wings broad, fore wings much spotted; in hind wings the bands not across, or only by connected spots..... *hispanus* L.
Abdomen with the segments not banded, sometimes lineate or spotted...52.
52. Apical marks of hind wings in the form of two streaks.....53.
Apical mark of hind wings transverse or in spots.....57.
53. Stigmal band of hind wings not reaching across.....54.
Stigmal band of hind-wings reaching across..... *cataractæ* Per.
54. All marks in the form of streaks in both wings..... *radiatus* Rbr.
Some spots or bands.....55.
55. Spots netted; basal band of hind wings not reaching toward base; abdomen yellow with dark spots..... *tessellatus* Rbr.
Spots not netted; basal spot usually reaching toward base.....56.
56. Four stigmal spots in hind wings..... *incommodus* Walk.
Two stigmal spots in hind wings; a submarginal line in both wings..... *immensus* McL.
57. Two stigmal bands in hind wings (or broken into spots); a submarginal row of spots..... *cephalotes* Klug.
But one stigmal band in hind wings.....58.
58. Median band of hind wings reach across; small spots along hind border; abdomen dark, not spotted.....60.
Median band not across; hind wings with many small spots; abdomen yellow, lineate with dark.....59.
59. Abdomen with small spots and dots; bands of wings netted... *percheroni* Guer.
Abdomen lineate, or mostly dark; spots in hind wings not netted..... *libelluloides* L.
60. Stigmal and median bands of hind wings connected; apical mark of hind wings entire..... *walkeri* var.
These bands separated.....61.
61. The stigmal band of hind wings is connected or nearly so to the apical which extends along the hind border.....62.
The stigmal not connected to apical, and latter not extending along the hind border; hind wings very broad in the middle..... *walkeri* McL.
62. Hind wings quite narrow; from North Africa..... *angustus* McL.
Hind wings quite broad in middle; from Madagascar..... *martini* Weele.

Palpares gigas Dalman.

Figure—Plate XIX, Figure 17, and Drury, Pl. 41.

The fourth anal of f. w. with three or four branches and three cross-veins; the third anal in h. w. has a strong oblique vein up to second anal. Male appendages nearly twice as long as the last two segments together.

Palpares mœstus Hag.

Figure—Plate XIX, Figure 15; Hagen, Mozambique paper.

The fourth anal in f. w. with four or five branches and five or more cross-veins; the third anal of h. w. practically runs into the second, and with two or three cross-veins before it. The antennæ are longer than in *P. gigas;* the thorax with long white hair. Anal appendages of male, Fig. 55.

Palpares obscuripennis Schmidt.

In general this resembles a very large *P. spectrum* but the fore wings are plainly tinged with pink; the pale basal part of hind wings is milky and the black has no complete pale bands, but median and stigmal pale bands reaching one-half way across wing, two spots near apex, and two to four near the hind border.

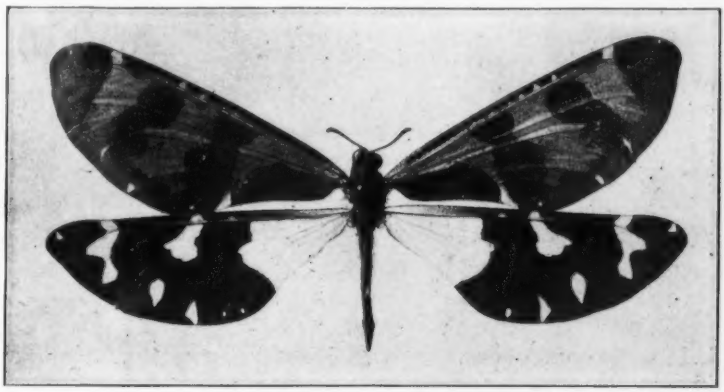


Fig. 1. *Palpares obscuripennis* Schmidt.

I have seen it only in the Stettin (type) and Berlin Museums. It may be the *P. fulvus* McLach; but I was not able to find McLachlan's type in his collection nor elsewhere.

Palpares martini Weele.

Figure—Van der Weele, Madagascar, Figure 3.

This species resembles *P. walkeri*, and in that species the apical mark sometimes almost connects to the stigmal band.

Palpares cataractæ Pering.

Figure—Peringuey; and Stitz (as *obscuratus*).

Third anal in h. w. runs into the second, and is connected once or twice to the fourth anal.

This has been redescribed by Stitz as *P. inclemens* W. var. *obscuratus*.

Palpares vœltzkowi Kolbe.

Figure—Van der Weele, Madagascar, Figure 4.

A remarkable species, not only on account of the almost wholly black hind wings, but also in the very slender abdomen. Van der Weele figures (p. 255) the male appendages.

Palpares insularis McLach.

Figure—Van der Weele, Madagascar, Figure 6, also the male appendages on page 259.

Fourth anal of f. w. with three branches and one or two cross-veins to the third anal. Third anal of h. w. simple, two or three cross-veins to second, none to fourth anal. Black band below antennæ present.

P. hildebrandti is the same species.

Palpares amitinus Kolbe.

Figure—Van der Weele, Madagascar, Figure 7.

Fourth anal of fore wings long, with four branches and four or five connections to the third anal; third anal of hind wings simple, with two cross-veins to the second, none to the fourth. The legs are black; there is a large interantennal mark reaching much below the antennæ as well as above from eye to eye; the outer apical margin of the fore wings is slightly sinuated, as in several other species.

Van der Weele also figures (p. 262) the male appendages which are short like those of *P. speciosus*.

Palpares furfuraceus Rambr.

Figure—Navas (as *equestris*), Broteria, X, p. 56.

Readily known by the greatly swollen vertex and fulvous hair on thorax, which was noted by both describers. It occurs in West Africa.

Palpares sobrinus Pering.

Figure—Peringuey, 1911, p. 33, Figure 3.

I can find no differences between this species and *P. nudatus* Navas; but I have not seen the type of either species; but judge from the figures and descriptions.

Palpares nyicanus Kolbe.

Figure—Kolbe, original; and Peringuey, 1911, p. 32, Figure 1 (as *æmulus*).

The third anal of h. w. runs apparently into the second, and with four or five cross-veins to the fourth anal.

P. æmulus Pering is, I think, the same species, and it is also figured by Calvert, Proc., Acad., Nat., Sci., Phil. 1899, plate X, fig. 2.

Palpares abyssinicus Kolbe.

The third anal of h. w. is simple, and no cross vein to fourth.

This species is very close, if not identical, with *P. nyicanus*, the spots are arranged in oblique streaks.

Palpares sparsus McLach.

Figure—Peringuey, 1911, p. 32, Figure 2.

The third anal of h. w. is simple, and no connection to fourth anal, but one to second. The fourth anal in f. w. is once or twice forked, and with two cross-veins. No band below antennæ.

Palpares radiatus Rambr.

Figure—Rambur, original.

The fourth anal in f. w. with three or four branches, and two or three cross-veins; the third anal in h. w. runs into the second anal. The male appendages (Fig. 40) are curved and as long as the last segment, and enlarged a little at tip. There is no band under the antennæ.

There are but few specimens of this in European collections.

Palpares incommodus Walk.

Figure—Plate XVIII, Figure 2, and by Stitz (*rubescens*) and by Navas (as *rieli*).

The third anal of h. w. appears to run into the second, two cross-veins behind to the fourth anal. In fore wings there is no line near the outer margin parallel thereto, but oblique streaks outward.

P. costatus Navas is also this same species as well as *P. rieli* and *P. rubescens* Stitz.

Palpares latipennis Rambur.

Figure—Plate XVIII, Figure 1.

The fourth anal of f. w. has three or four branches and four or five cross-veins to the third anal. The third anal of h. w. is simple, with several cross-veins to the second and one or two to the fourth anal.

The *P. furfuraceus* of Walker (not of Rambur) is this species, Walker's identification of *P. cephalotes* is also this species. *P. prætor* Gerst. is this species.

Palpares inclemens Walk.

Figure—Plate XVIII, Figure 5.

The third anal of h. w. runs into the second anal and with one or two cross-veins to fourth. The fourth anal of f. w. has three or four branches and four cross-veins to the third.

Sometimes the basal spot of hind wings is narrowly connected to the median. The wings especially the front pair are slightly sinuated on the outer margin.

Palpares immensus McLach.

Figure—Plate XIX, Figure 22, and Plate XXI, Figure 42.

Third anal of h. w. with a strong oblique cross-vein up to second, and a cross-vein behind to the fourth anal; fourth anal of f. w. with three or four branches and as many cross-veins; the third anal has but one fork.

P. kalahariensis Stitz is this species.

Palpares cephalotes Klug.

Figure—Klug; original description, and Plate XX, Figure 30 (*sollicitus*) and Figure 29 (*subducens*).

Third anal in h. w. simple, with two or three cross-veins to the second, and one to the fourth anal. No band under antennæ.

Walker's two species, *sollicitus* and *subducens* are *cephalotes* (as McLachlan has stated); the slight differences are only such as one finds in a series of many species of *Palpares*, *P. burmeisteri* Hagen (that is *P. cephalotes* Rambr) is probably the same species.

Palpares karrooanus Peringuey.

Figure—Peringuey, 1910, Plate VIII, Fig. 1.

Third anal in h. w. with one or two cross-veins to fourth anal; abdomen entirely reddish.

Although it has the hind wings almost wholly black as in *P. voeltzkowi* it is not related to that species, as all the marks are different; it is more nearly related to *P. radiatus*.

Palpares oneili Pering. (**Golafrus**).

Figure—Peringuey, 1911, p. 35, Figure 4.

Navas has made a new genus for it on account of the excised basal margin of the fore wings, but this is probably found only in the male, otherwise the species is related to *P. radiatus*. It was described as a female, but the tip of abdomen appears broken and the very narrow wings are similar to those of male *immensus*.

Palpares similis Stitz.

Figure—Calvert, (1889), Plate X, Figure 1.

This species is related to *immensus* by the submarginal line in fore wing, but the median and stigmal bands of hind wings are broader behind than in front; there is a spot above the cubital fork; in both wings the apical marks are in the form of streaks.

Palpares reticulatus Stitz.

Figure—Navas, with original description (as *extensus*).

The third anal in h. w. has one cross-vein to the fourth anal. The description of Stitz seems to have the priority.

Palpares obsoletus Gerst.

Figure—Plate XX, Figure 43, and Navas (as *nebulo*).

The fourth anal of f. w. has three or four branches and two connections to the third; in h. w. the third anal is simple, with one or two cross-veins to the second and none to the fourth. There is a black band below the antennæ.

Palpares normalis Navas.

Figure—Navas, with original description.

I have not seen this species, but it appears to be good, so long as species are based on markings.

Palpares geniculatus Navas.

Figure—Navas (with description.)

I have not seen it, but apparently distinct.

Palpares klugi Kolbe.

Figure—Klug, Plate, Figure 3 (unnamed).

Fourth anal in f. w. with two branches and connected three times to third; the third in h. w. runs into second and then away, with a cross-vein before.

Palpares tristis Hag.

Figure—Hagen, Mozambique and Kolbe. Plate XXI, Figure 51, appendages.

The fourth anal in f. w. has two or three branches, and two or three cross-veins; the third anal in h. w. simple, with a somewhat oblique cross-vein to the second anal. Nearly always there is a spot beyond the cubital fork in the h. w.

The varieties *niansanus* Kolbe, and *brevifasciatus* and *ugandanus* of Stitz are structurally very similar to the type form, but *brevifasciatus* is perhaps closer to *interioris*.

Palpares interioris Kolbe.

Figure—Plate XXI, Figure 49.

The fourth anal of f. w. has two or three branches, and two or three cross-veins; the third anal of h. w. is simple, with two connections to the second. The marks are very similar to those of ***obsoletus***, but that species is larger than *interioris*, and the body markings somewhat different.

Palpares lentus Navas.

Figure—Plate XXI, Fig. 47, Navas, original description.

Third anal of h. w. simple, one cross-vein to the second, none to fourth anal. A black band below antennæ. Male appendages short, Fig. 36.

Palpares pardaloides Weele.

Figured by Van der Weele, Madagascar, Figure 5; also the male appendages on page 257.

Fourth anal of f. w. with four branches and two cross-veins; third anal of h. w. simple, no cross-vein to second. Legs deep black.

In the Brussels Museum is a long series from Madagascar that tends to connect this species to *P. insularis.*

Palpares nigrita Navas.

Figure—Plate XIX, Figure 27, and Navas, original.

Fourth anal in f. w. with two branches and two cross-veins; third anal of h. w. simple, and one straight cross-vein to the second anal. No band under antennæ.

P. languidus Navas appears also to go here, but the figure of the hind wing is broader than usual.

This is a species that stands in the Rambur collection with the label *P. manicatus R., P. tigris Walk. var. de tigris Dalm,* and also a label "Seneg" Rambur's *manicatus* according to him had two radial sectors like *tigris,* and with no locality label, so I cannot believe that this specimen is Rambur's type of *P. manicatus.* I figure the hind wing of this specimen, (figure 27).

Palpares walkeri McLach.

Figure—Plate XIX, Figure 21; Navas, Broteria X, p. 35.

Fourth anal of f. w. with two or three branches, and two cross-veins; third anal of h. w. simple, three or more cross-veins to second, and one to fourth. No band under antennæ.

P. dispar Navas seems to be the same species.

Palpares angustus McLach.

Figure—Plate XVIII, Figure 7.

Fourth anal in f. w. with three branches, and four cross-veins; third anal of h. w. has an oblique cross-vein to second and two cross-veins before it. Legs all deep black; the stigmal band of the hind wings sometimes has an upper inner projection. There is no band under antennæ.

The variety *oranensis* grades into the type.

Palpares hispanus Linn.

Figure—Navas, Insecta, 1911, p. 265.

The fourth anal of f. w. has one or two short branches and two cross-veins; the third anal of h. w. is simple, with an oblique cross-vein to second, but none to fourth. The marks on the abdomen (Fig. 33) are very characteristic; as in other species there is much variation in the extent of the marks on wings, and in the width of the hind wings.

Palpares libelluloides Linn.

Figure—Many figures in European literature.

The fourth anal of f. w. is very short and curved, with one or two branches and one or two cross-veins. The third anal of h. w. is simple, with slightly oblique cross-vein to the second and none to the fourth anal.

P. chrysopterus Navas is the same or a slight variety.

Palpares tessellatus Rbr.

Figure—Plate XX, Figure 32 (marks of abdomen), and Stitz (as *annulatus*).

The fourth anal of f. w. has two branches, and one or two connections; the third anal of h. w. is simple with one or two straight cross-veins. No dark band under the antennæ.

P. annulatus Stitz is a synonym of this species.

Palpares percheroni Guerin.

Figure—Guerin, Iconog. Regn. Anim., Plate 62; Gray, Anim. Kingd., Plate 127, Figure 1.

The fourth anal of f. w. has two branches and one or no connection to third; the third anal in h. w. simple, with a somewhat oblique cross-vein to second anal. The male appendages are long and curved. The abdominal marks are figured on Plate XX, Figure 31.

Palpares tigris Dalm. (**Nosa**).

Figure—Navas (*calceata, leonina, lupina, pardina,* and *hamatus*).

The fourth anal of f. w. has two or three branches and two or three connections to the third; the third anal of h. w. is simple, connected twice to the second and sometimes once to the fourth.

P. manicatus Rbr. is this species according to his description. *P. hamata* is a male. *P. tigris, calceata, hamata, sylphis* have quite large spots; *P. leonina, lupina* and *pardina* have smaller spots. Tip of fore wing, see figure 45.

Palpares ægrotus Gerst.

Figure—Navas (as *longicornis*), Kolbe (as *submaculatus*), and Stitz (as *paucimaculatus*).

The fourth anal of f. w. with one or two branches and two connections to the third; third anal of h. w. simple, with one cross-vein to second, none to the fourth.

Variety *taborensis* Stitz is apparently the same. Tip of the fore wing, see figure 46. *P. dilatatus* Navas has stigmal spots united into a band.

Palpares ornatus Navas.

Figure—Navas (with description).

Very close to *ægrotus* and perhaps a form of it, but the apical marks are different, and these in *ægrotus* seem very constant.

Palpares speciosus Linn.

Figure—Romer, Genera, Plate XXV, Figure 3; De Geer, Mem. III, Plate XXVII, Figure 9, (as *maculatus*); also Sulzer, Plate XXV, Figure 3.

The fourth anal of f. w. with two branches, and two cross-veins; the third anal of h. w. simple, with two cross-veins to second, but none to the fourth.

A peculiar variation in marking is seen on Plate XX, Fig. 37, hind wing; and male appendages Figs. 52, 53.

Palpares dubiosus Pering.

I have not seen this species nor is there any figure, but it is described as close to *P. speciosus*, so it is probably but one form of what will prove to be one common variable species.

Palpares caffer Burm.

Figure—Plate XXI, Figure 50.

The fourth anal of f. w. with two branches and two cross-veins to third; the third in h. w. simple, with one cross-vein to the second, but none to the fourth.

The difference between this and *P. speciosus* is hardly sufficient for a species, and not constant; the wings are usually shorter than in *P. speciosus*, and the fore pair less heavily marked.

Palpares varius Navas.

Figure—Navas, original description.

In fore wing the fourth anal has two branches and two connections; in hind wings the third anal is simple with two connections to second, but none to fourth.

Palpares digitatus Gerst.

Figure—Calvert, Figure 3 (unnamed); Navas (as *torridum* and *pobeguini*); and Plate XIX, Figure 24.

In fore wing the fourth anal has one branch and one cross-vein. Third anal in h. w. simple, not connected to fourth anal, with two veinlets to the second anal.

The figure I give and that of Navas represent heavily marked specimens; that of Calvert is more normal. I think *P. umbrosus* Kolbe is the same; but the bands are narrower and one or more "fingers" are usually separate from the bands, and the wings may be a little more slender, in fact it is more like *P. speciosus*, and appears to connect *speciosus* with *digitatus*. The hind wings of typical *umbrosus* are shown in figure 44.

Palpares stuhlmanni Kolbe.

Figure—Kolbe, Figure 1.

Closely related to *P. speciosus*, at least in the male appendages; the marks are similar to those of *P. umbrosus*; the venation is as in *P. speciosus*

Palpares damarensis McLach.

Figure—Plate XVIII, Figure 11, and Stitz (as *bifasciatus*)..

Fourth anal in f. w. with two or three branches and two cross-veins; third anal of h. w. simple, no connection to the fourth. Black hair on clypeus; legs all black; head all dark, except pale clypeus.

Palpares formosus Banks.

Figure—Plate XIX, Figure 23; also Navas in Broteria X, p. 85, Figure 16.

Fourth anal in f. w. with one short branch, and one cross-vein; third anal of h. w. simple with one cross-vein to second and none to the fourth.

Palpares festivus Gerst.

Figure—Peringuey (as *mosambicus*), and Navas (as *latro*).

The third anal of h. w. simple, and no cross-vein to the fourth. Legs black.

Palpares elegantulus Pering.

Figure—Peringuey 1910, Plate VII, Figure 4.

This small slender-winged species is apparently very distinct; I have not seen it, but it appears related to the *flavofasciatus* group.

Palpares flavofasciatus McLach.

Figures—Peringuey (as *genialis*); Stitz (as *guttatus*); and Navas (as *nyassensis*)

The third anal in h. w. is simple and no connection to the fourth anal. Legs black.

In *P. nyassensis* the bands are a little wider than in the other types, but a series of specimens shows much variation in this point.

Palpares compositus Navas.

Figure—Navas (and also as *mistus*).

Closely related to *flavofasciatus*, but with the bands of hind wings much broader and connected. *P. mistus* Navas appears to be the same form. It is in the Berlin Museum under a manuscript name that I cannot find has ever been published.

Palpares bifasciatus Oliv.

Figure—Plate XVIII, Figure 6.

Fourth anal in f. w. with two branches, and two cross-veins; the third anal of h. w. simple, connected about four times to the second and twice to the fourth. A broad black band under antennæ; abdomen pale yellowish red; thorax with two rows of yellow spots.

This was considered by Walker as *P. pardalinus* Burm. McLachlan doubted it, and so named Walker's insect *P. brachypterus;* but Hagen (who saw both) asserts that Walker's insect is *pardalinus* B. It agrees with the *Mymeleon bifasciatum* Olivier.

Palpares spectrum Rambr.

Figure—Navas, Rev. Zool. Afric., II, p. 37.

The fourth anal of f. w. has two branches and two connections; the third anal of h. w. is simple, with one cross-vein to second, but none to fourth anal.

Palpares rothschildi Weele.

Figure—Stitz, Figure 10.

The fourth anal in f. w. has two branches and two connections; the third anal in h. w. is simple, and one cross-vein to second anal.

Very closely related to *P. spectrum* and probably but a local variety, occuring northward of the range of *P. spectrum.*

Palpares ovampoanus Pering.

Figure—Peringuey, 1910, Plate VII, Figure 1.

This is closely related to *P. spectrum* and will fall in the subgenus *Palparellus.* I have not seen specimens in European collections.

Palpares translatus Walk.

Figure—Plate XVIII, Figure 13.

The third anal in h. w. is simple, and not connected to the fourth anal. Antennæ close together at base; subcosta not thickened, but in general structure is closely related to *Pamexis luteus.*

Palpares luteus Thunberg. (**Pamexis**).

Figure—Plate XVIII, Figure 9.

The third anal in h. w. is simple, and connected once to the fourth anal.

P. venosus Burm. is the same; and Hagen asserts (and he has examined both types) that *P. conspucatus* Burm. is also the same species. The subcosta is thickened in both sexes, otherwise the species is related to *P. translatus.* There are specimens in the Berlin, Brussels and British museums.

Palpares contaminatus Hagen.

Figure—Plate XVIII, Figure 4.

This name was given by Hagen (Can. Entom. 1887, p. 112) for *P. pardalinus* Rambur, not of Burmeister. I figure the hind wing of the type. The subcosta of fore wing is not thickened.

INDIAN SPECIES.

1. A large spot over the fork of the cubitus in the hind wing....6.
   No such spot....2.
2. An elongate spot along middle of hind margin of hind wing; median band does not reach across....*tigroides*
   No such spot; median reaches across....3.
3. Fore wings mostly dark, leaving only large and small pale spots, rather small species....*astutus*
   Fore wings, mostly pale, with dark bands or spots....4.
4. Margin of fore wings plainly sinuate; some bands of both wings reach across; large species....5.
   Margin of fore wings not sinuate, bands of fore wings not across; hardly across in the hind wings....*papilionoides*
5. Tips of hind wings plainly falcate; stigmal band without projection toward median band....*falcatus*
   Tips not falcate; stigmal spot with projection toward the tip of the median band....*contrarius*
6. Two parallel stigmal bands, or spots....7.
   But one stigmal band, or broken into one series of spots....9.
7. Both median and stigmal bands in hind wings reach across....8.
   Neither median nor stigmal reach across; margins of both wings narrowly dark....*astarte*
8. Median connected to basal spot; latter reaching across hind wing...*patiens*
   Median not connected to the basal, which does not reach across....*infirmus*
9. Apical mark of hind wings solid; stigma very broad and reaches across..*solidus*
   Apical mark with spots, or broken; stigmal band not very broad nor reaching across....10.
10. A spot behind radius above the basal spot on the cubital fork of the hind wings; stigmal mark running obliquely inward....*zebratus*
    No spot behind radius; stigmal band extending outward, or curved inward..*pardus*

Palpares astarte n. sp.

Figure—Plate XIX, Figure 18.

Head yellowish; a row of pale hairs across clypeus, and on margin of labrum; a black spot narrowing behind on vertex, continued over thorax as a median stripe, widest on the mesothorax, dark stripe on sides of pronotum, and stripe on meso and metathorax over base of the wings; abdomen yellowish brown, a black spot on apex of the first segment; legs and sternum all black. Wings rather yellowish, and with yellowish venation; costa black, and with black points out on costals, but costals are pale; outer posterior margin of both pairs of wings dark brown; fore wings with five series of spots; a long streak on cubitus broader at tip and bending down; a spot above it behind the radius; an oblique band beyond the streak reaching from radius to more than one-half way across; beyond this are two spots in an oblique row; then three spots in a transverse row, one stigmal, the other two in form of streaks; the two subapical marks are not quite streaks. In hind wings is a spot on cubital fork, a band beyond reaching to beyond middle where it is enlarged; a curved band beyond this, not reaching either radius or hind margin, larger behind; then two large spots, one stigmal, the other close behind it; then a sinuous band before apex. Wings of moderate breadth; in fore wing the third anal is connected to the fourth four or five times, in hind wings the third anal has an oblique vein running into the second anal, and one cross-vein beyond it. Expanse 125 mm.

From Chapra, Bengal, India (Mackenzie).

Palpares pardus Rambr.

Figure—Plate XVIII, Figure 3, and anal appendages, Plate XXI, Figure 54.

The fourth anal of f. w. has three or four branches and three cross-veins; the third anal in h. w. is simple, with two cross-veins to second.

P. expertus Walk is the same species; it is very common in India.

Palpares zebratus Rambr.

Figure, Plate XX, Figure 28.

The third anal of h. w. simple, with two to four cross-veins to second and one to three to fourth anal. Abdomen with a median dark stripe above. The fore wings are without distinct bands, but with median and stigmal spots.

Palpares contrarius Walk.

Figure—Plate XVIII, Figure 8.

The third anal of h. w. simple, with two cross-veins to the second, one of which is slightly oblique, in the f. w. the fourth anal has two branches and two or three connections.

This is a beautiful species not uncommon in Ceylon. In Walker's description a line is omitted regarding the second band in the hind wings, for it is this band that has a projection toward the first band.

Palpares falcatus McLach.

Allied to *contrarius* in markings, but hind wings more falcate; I have seen only the type.

Palpares patiens Walk.

Figure—Plate XVIII, Figure 10, and Navas in Broteria X, p. 86, Figure 17.

The third anal of h. w. runs into the second, and a cross-vein behind to fourth anal; abdomen dark, unmarked.

Palpares infirmus Walk.

Figure—Plate XVIII, Figure 12.

The third anal of h. w. with an oblique vein to the second, one cross-vein before it to second, and one behind to fourth anal. No band under antennæ.

This is probably the same species as *P. patiens*. Fore wings with many spots, and streaks and spots along the outer hind margin, stigmal and median bands small.

Palpares papilionoides Klug.

Figure—Klug, Plate, Figure 2.

The third anal in h. w. is simple, no cross-vein before the oblique one running into second.

It is not common and is represented in but few European collections.

Palpares solidus Gerst.

Figure—Plate XIX, Figure 20; and Navas (as *klapaleki*).

The fourth anal in f. w. is two or three branched, and with two or three connections; the third anal in h. w. is simple, with one cross-vein to second.

Palpares tigroides Walk.

Figure—Plate XX, Figure 34.

Third anal of h. w. simple, one cross-vein to the second and none to fourth anal. Legs black; fore wings with hardly any marks, rather yellowish.

Palpares astutus Walk.

Figure—Plate XIX, Figure 19.

The fourth anal of f. w. with two branches, and two cross-veins; the third anal of h. w. simple, with one cross-vein to second. It belongs to the subgenus *Palparellus*.

STENARES.

(including *Crambomorphus*.)

1. Outer margin of wings strongly sinuate.....(*Crambomorphus*) 2.
   Outer margin of wings not plainly sinuate.....(*Stenares*) 3.
2. Hind wings pale with two large bands well separated, and apex marked....
   grandidieri Weele.
   Hind wings with the bands so large they are connected and cover most of surface, leaving only pale spots.....*sinuatum* Oliv.
3. Hind wings with all the bands broad and connected, leaving only pale spots..
   madagascariensis.
   Hind wings not so heavily marked.....4.
4. No stigmal spot in hind-wings, a streak along outer edge, and sometimes a few dots before it; wings very narrow; in hind wings costals at base are crossed.
   hyæna.
   A stigmal spot reaching nearly one-half way across.....5.
5. A spot on hind wings just beyond the cubital fork, also large median band; wings broad; in hind wings the costals are mostly simple.....*irroratus*.
   No spot on hind wings near the cubital fork, but median spots (or band) are sometimes present; in the hind wings the costals are mostly crossed....6.
6. Larger; apical mark of the hind wings in the form of two streaks....*improbus*.
   Smaller; apical mark of the hind wings entire, or partly broken, not in form of streaks.....*harpyia*.

In *S. hyaena, irroratus, improbus* and *harpyia* the third anal of h. w. runs into the second, with one or three cross-veins before; all have a pale pronotum with a median black stripe, and all have black legs.

Stenares (Crambomorphus) grandidieri Weele.

Figure—Weele, Madagascar, Fig. 2.

Differs much in markings from *S. sinuatus;* fully half of the hind wing is hyaline; the wings are also much broader than in that species, but the hind wing shows the same costal swelling at apex. The anal venation is similar to that of *S. sinuatus*, but in the h. w. the third anal has but one cross-vein to the fourth anal.

Stenares (Crambomorphus) sinuatus Oliv.

Figure—Plate XIX, Fig. 14.

Hind wings black; two pale spots in middle and stigma pale, and pale spots on hind border.

Fourth anal in f. w. has four branches and four connections; in h. w. the third anal is long, with an oblique cross-vein to the second and others nearly erect, and four cross-veins to the fourth anal.

Palpares hæmatogaster Gerst. is the same species.

Stenares irroratus Navas.

Figure—Navas, original.

I have seen only the type in the British Museum.

Stenares improbus Walk.

Figure—Plate XIX, Figure 16, and male appendages, Figure 25.

In h. w. the third anal runs into the second, and has two cross-veins to fourth; in f. w. the fourth anal has five branches and five cross-veins to the third.

Stenares harpyia Gerst.

Figure—(Anal appendages) Plate XIX, Fig. 26.

The fourth anal of f. w. has many branches and many connections to the third anal; in h. w. the third anal runs into the second, and has two branches.

Stenares madagascariensis Weele.

Figure—Van der Weele, Madagascar, Fig. 1.

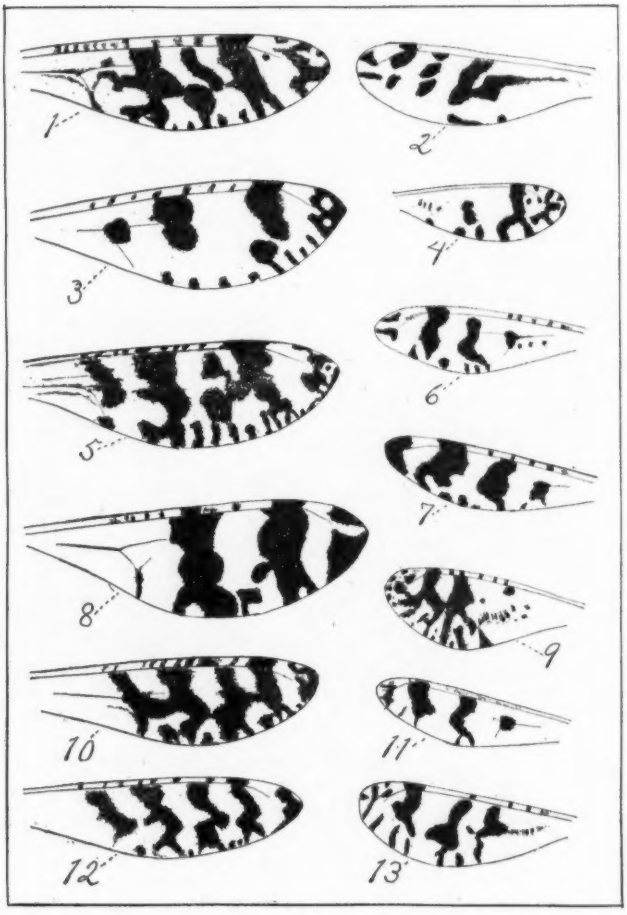
The third anal of hind wing is simple, with an oblique cross-vein to second and two or three before it, and four or five cross-veins to the fourth.

Stenares hyæna Dalman.

Hagen considers the figure 12, plate 86, of the Fourth volume of Seba's Thesaurus as representing the species.

EXPLANATION OF PLATES XVIII TO XXI.

Fig. 1. Palpares latipennis, hind wing.
Fig. 2. Palpares incommodus, hind wing.
Fig. 3. Palpares pardus, hind wing.
Fig. 4. Palpares contaminatus, hind wing.
Fig. 5. Palpares inclemens, hind wing.
Fig. 6. Palpares bifasciatus, hind wing.
Fig. 7. Palpares angustus, hind wing.
Fig. 8. Palpares contrarius, hind wing.
Fig. 9. Pamexis luteus, hind wing.
Fig. 10. Palpares patiens, hind wing.
Fig. 11. Palpares damarensis, hind wing.
Fig. 12. Palpares infirmus, hind wing.
Fig. 13. Palpares translatus, hind wing.
Fig. 14. Stenares sinuatus, hind wing.
Fig. 15. Palpares mœstus, apex of hind wing.
Fig. 16. Stenares improbus, hind wing.
Fig. 17. Palpares gigas, apex of hind wing.
Fig. 18. Palpares astarte, fore and hind wings.
Fig. 19. Palpares astutus, fore and hind wings.
Fig. 20. Palpares solidus, hind wing.
Fig. 21. Palpares walkeri, hind wing.
Fig. 22. Palpares immensus, hind wing.
Fig. 23. Palpares formosus, hind wing.
Fig. 24. Palpares digitatus, hind wing.
Fig. 25. Stenares improbus, male appendage.
Fig. 26. Stenares harpyia, male appendage.
Fig. 27. Palpares nigrita, hind wing.
Fig. 28. Palpares zebratus, hind wing.
Fig. 29. Palpares subducens hind wing.
Fig. 30. Palpares sollicitus, hind wing.
Fig. 31. Palpares percheroni, abdomen.
Fig. 32. Palpares tessellatus, abdomen.
Fig. 33. Palpares hispanus, abdomen.
Fig. 34. Palpares tigroides, hind wing.
Fig. 35. Palpares latipennis, and amitinus, anal area of fore wings.
Fig. 36. Palpares lentus, male appendages.
Fig. 37. Palpares speciosus, variation of hind wing.
Fig. 38. Palpares insularis, anal area, fore wing.
Fig. 39. Palpares inclemens, anal area, hind wing.
Fig. 40. Palpares radiatus, male appendages.
Fig. 41. Palpares umbrosus, male appendages.
Fig. 42. Palpares immensus, male appendages.
Fig. 43. Palpares obsoletus, hind wing.
Fig. 44. Palpares umbrosus, hind wings, of two males.
Fig. 45. Palpares tigris, apex of fore wing.
Fig. 46. Palpares ægrotus, tip of fore wing.
Fig. 47. Palpares lentus, hind wing.
Fig. 48. Palpares extensus, hind wing.
Fig. 49. Palpares interioris hind wing.
Fig. 50. Palpares caffer, hind wing.
Fig. 51. Palpares tristis, male appendage.
Fig. 52. Palpares speciosus, male appendage, side.
Fig. 53. Palpares speciosus, male appendage, above.
Fig. 54. Palpares pardus, male appendage.
Fig. 55. Palpares mœstus, male appendage.



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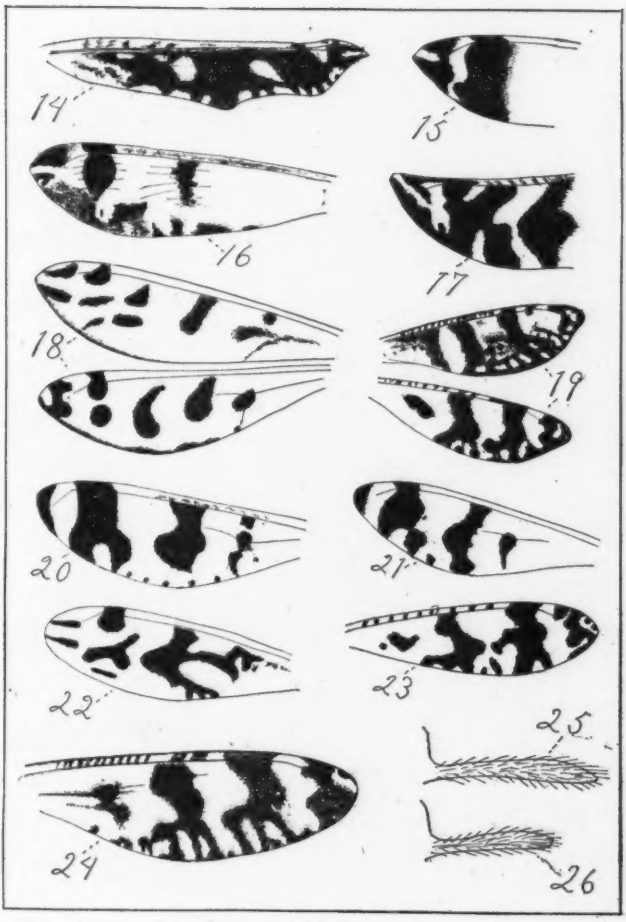

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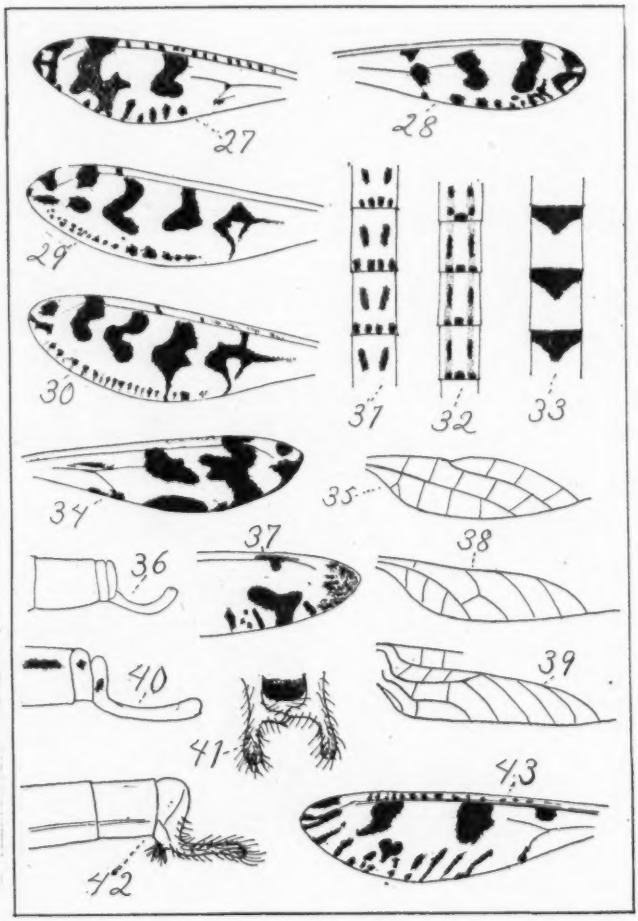

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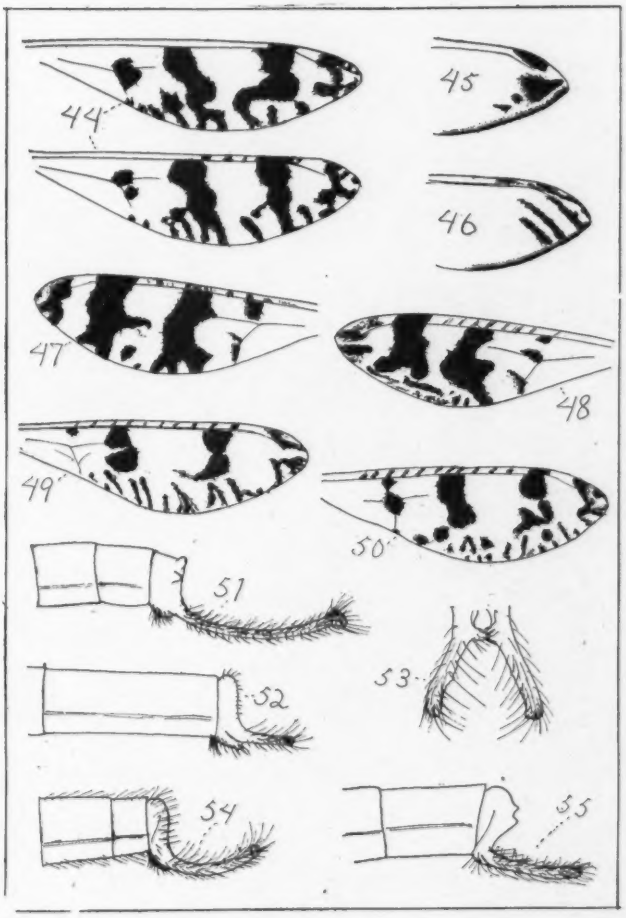

N. Banks.

STOMOXYS CALCITRANS LINN, PART II.*

By CHAS. K. BRAIN.

The Circulatory System.

The circulatory system in *Stomoxys calcitrans* consists, as in other Diptera, of the dorsal vessel or heart, and its anterior continuation, the thoracic aorta. The dorsal vessel extends as a delicate tube from the posterior part of the abdomen to its anterior sixth, that is above the anterior part of the sucking stomach, where it becomes narrowed into the thoracic aorta. This narrowed portion continues of uniform thickness until the proventriculus is reached, where it becomes somewhat flattened and wider. Beyond this it becomes narrower, and terminates above the esophagus, between the proventriculus and the neck.

It may be noticed that, as found by Professor Minchin in his study of Glossina sp., the dorsal vessel ends blindly behind, is composed of similar giant cells, and has similar ostia and alary muscles. The number of chambers in the heart was not determined with certainty, but I think Tulloch was correct in supposing that there were four. The dorsal vessel lies free in the pericardial cavity, but is supported by the muscular pericardial septum.

Nervous System.

There are two chief ganglia, viz: the brain and the thoracic ganglion, and from these the main nerve-trunks arise. Time was not taken to work out the more minute nerves, but the following may be mentioned. The chief nerves of the head beyond those of the compound eyes, are those which enervate (a) the antennae, (b) the ocelli, and (c) the esophagus, pharynx, and the pharyngeal muscles.

The brain is connected with the thoracic ganglion by commissures, between which the esophagus passes. The thoracic ganglion is roughly pear-shaped, and is supported by the internal chitinous skeleton of the thorax. The main nerves given off from the thoracic ganglion are (a) six pairs which

*The first part of this paper, which dealt with the external mouthparts and the digestive system, appeared in Vol. V, No. 4, pp. 421–430 of these ANNALS, December, 1912.

supply the thoracic muscles, and (b) the abdominal nerve trunk, which arises as a stout continuation of the posterior part of the ganglion. This nerve trunk gives off fine branches to the abdominal muscles and on reaching the third abdominal segment, splits into three.

These three branches supply the reproductive organs, the ovaries or testes, and the ovipositor or the penis.

Reproductive System.

The male generative organs, (Plate XXII, Fig. 7.) are comparatively simple in structure. They are however not readily seen in gross dissection until some of the surrounding and over-lying Malpighian tubules are moved. They consist of a penis, ejaculatory duct, vesicula seminalis, and testes with their ducts.

The testes are smooth, spherical bodies, enclosed in sacs which have deeply pigmented walls, giving them a deep orange color. From the lower end of each testis a delicate tube arises, short and straight, which runs down to join the duct from the opposite side, as the upper limbs of a Y.

From this junction an exceedingly short length of common duct enters the bulbous upper end of the tubular organ, which would seem to serve as a vesicula seminalis. This is a flexible tube, often seen lying with one or two U-shaped bends in its course. At its upper end this vesicula seminalis is bulbous, gradually narrowing below to form the ejaculatory duct, (Fig. 7, e. d.), which crosses the rectum dorsally from left to right, to enter the penis in front of it.

The female reproductive organs, (Pl. XXII, Fig. 8) are of the house fly type. There are two ovaries, each consisting of some 60 ovarioles. The ovaries vary in size according to the degree of maturity of the lowest ova, of which there are never more than four in a single ovariole. In some cases the ovaries occupy more than half of the whole abdominal space. The ovarioles from one side open into a wide tubular duct which joins the similar duct from the other side like the arms of a Y.

As a result of this junction a common oviduct (o. v.) results, which runs down forming a long third limb to the Y. Below the attachment of the uterine appendages the oviduct continues as the uterus. The appendages consist of the uterine glands and the receptacula seminis.

The uterine glands, (u. g.), are two rather stout tubular organs with slightly bulbous extremities. The bulbous end is firmly joined to the lateral oviduct by a very short double strain of connective tissue.

The receptacula seminis are two small, black, spherical bodies, each with a cellular socket resembling the fitting of an acorn cup. From this runs a very fine duct which enters the division between the oviduct and the uterus in the mid-dorsal line. The receptacula are attached to each other but can be separated by dissection. The uterus is a tube of the same diameter as the common oviduct above, and runs down the middle line into the ovipositor.

The ovipositor consists of three cylindrical segments of thin chitin which usually lie telescoped inside the abdomen.

Habitat.

Farmyards and stables are evidently the favorite haunts of this fly. It occurs also in fields and open woods, especially where cattle or horses are grazing. It is evidently by no means uncommon even in large cities, and numbers have been seen in quite busy streets. It is fond of resting on surfaces fully exposed to the sun, such as doors, gates, and rails, and to a less extent also on stone walls. Painted surfaces seem to be specially attractive to it. Its flight is quite inaudible at a short distance. When disturbed it frequently returns to the same spot, as though it were a favorite resting place. It is quite active during the warmer part of the day, and at night returns to some sheltered spot such as the beams in a shed. In Columbus the numbers of this species dwindled towards the end of October in 1912, but a few could be caught up to the end of November, and four specimens were taken on December 3rd. In captivity these flies live but a short time, generally less than a week. They frequently clean their wings, performing their cleaning with great precision, the hind pair of legs being used for this purpose. The lower surface is combed; then the upper, the legs are then rubbed together and the process repeated.

Emergence from the egg.

The larva makes its escape from the egg by splitting the broad end of the groove, leaving it slightly raised, and apparently intact on the opposite side, Plate XXII, Figure 1.

The Larva. Plate XXII, Figs. 2 and 3.

Color creamy white to yellowish, shiny, greasy in appearance. The coiled alimentary tract, when filled with food, gives the posterior portion a dark appearance. The longitudinal tracheae may be recognized as two submedian white lines which show delicate lateral branches. The posterior stigmata are black, while the thoracic ones are yellowish in color.

In form the larva is elongate, tapering towards the head but broadly rounded behind. The segmentation is not very conspicuous, and the epidermis is bare, not having hairs nor bristles. On the head may be seen two large divergent mammiform processes, at the end of which are the minute retractile antennae, which are apparently each composed of four subequal segments. The mouth parts are strongly chitinised in the full grown larva and are composed of a number of sclerites as shown in Figs. 2 and 3.

The last seven segments are furnished, on their ventral surface, with raised bands of tactile tubercles. The posterior stigmata are two in number, circular, and somewhat distant from each other. The thoracic stigmata occupy a sub-lateral position on the third segment, and each consists of five circular orifices. (t. s.). These are connected with a large bilateral air sac which extends along the fourth segment.

Method of pupation.

The time taken for pupation is usually about two hours. The larva at first becomes quiet, and shortens rapidly, chiefly by the contraction of the anterior segments. In this way it assumes a form which resembles a barrel in shape. At this stage it is still yellowish white and the mouthparts of the larva are plainly visible through the soft integument. The color then changes to a bright yellow, and in about an hour longer it assumes the normal chestnut color of the puparium.

The puparium is from 5 to 6 mm. in length, only eleven segments are visible, the anterior one bearing the minute, bilateral, thoracic stigmata, while the broadly rounded posterior segment shows the disc-like posterior stigmata. Under optimum conditions this stage lasts from 9 to 13 days.

Development of the adult.

About three days before the emergence of the adult fly, the cuticle of the puparium darkens, and eventually splits along the lateral and median lines, anteriorly, and trans-

versely across the fourth segment. This section falls away and the fly escapes. Prior to this the nymph undergoes its final ecdysis, pushing its effete skin off backwards into the posterior end of the puparium. On its emergence it appears as a small dark fly, gray in color, with thick rudimentary wings of a dull leaden color. Its head is, at this stage, much wider than the thorax, and the abdomen is attenuated. At first it is very active, the period of activity evidently serving to allow the fly to force its way to the surface before the wings are fully grown and stiffened. The frontal sac is constantly inflated during this time, and no doubt serves in moving fragments of earth, etc. out of the way. When liberated the insect spends considerable amount of time in combing out the hairs on the arista of the antennae.

During this time the fly constantly changes its position, and the frontal sac is contracted. There are marked changes, too, in the abdomen and wings. The abdomen first becomes longer, and is constantly expanded and contracted, and gradually assumes its normal coloring, with the clove spots. The wings then begin to expand, a process which is completed in less than five minutes.

The fly is about its normal size, shape, and color at this time, but some time is taken in the final hardening of the integument, and in the final combing operations, which seem to be indispensible before flight. It is during this last process that the proboscis is at last raised into its horizontal position.

REFERENCES.

See Bibliography given in Part I, and also:

NEWSTEAD, R. 1907. Stomoxys calcitrans Linn. Ann. Trop. Med. and Parasit. Vol. I. 1907. Liverpool.

DESCRIPTION OF PLATE XXII.

Fig. 1. Egg, greatly enlarged, showing groove, and point of emergence of the larva, *e*.

Fig. 2. Lateral view of anterior segments of larva, showing *ant*, antenna; *m*, mandible; *h. s.*, hypostomal sclerite.

Fig. 3. Dorsal view of anterior segments of larva of Stomoxys calcitrans. *m*, mandible; *t. s.*, thoracic spiracle.

Fig. 4. Openings of thoracic spiracle.

Figs. 1, 2, 3 and 4. After Newstead.

Fig. 5. Semi-diagramatic view of adult fly. See Part I.

Fig. 6. Salivary glands and left Malpighian tube of adult, see Part I.

Fig. 7. Male reproductive organs: *t*, testis; *v. s.*, vesicula seminalis; *e. d.*, ejaculatory duct; *r*, rectum.

Fig. 8. Female reproductive organs: *o*, ovary; *ov*, oviduct; *u. g.*, uterine gland; *u*, uterus; *r. s.*, receptacula seminis.

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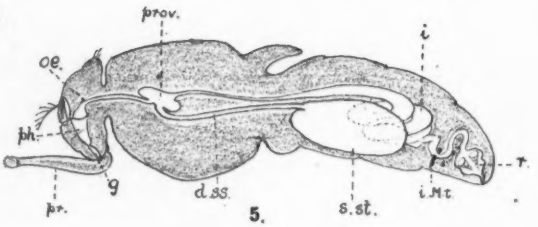

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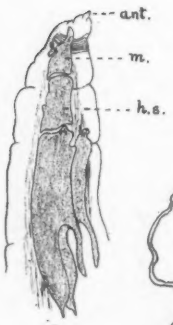

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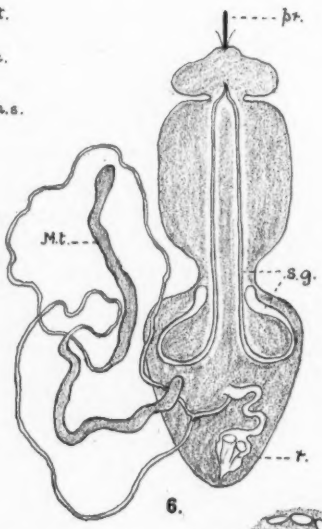

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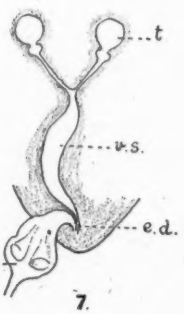

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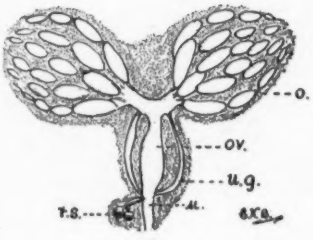

8.

C. K. Brain.

THE BIOLOGY OF PERLA IMMARGINATA SAY.*

By Lucy Wright Smith.

Introduction. Perhaps less is known concerning the life-histories and habits of the Plecoptera than of any other group of aquatic insects. Hence a more extensive knowledge of stone-flies along biological lines is desirable. At the suggestion of Professor James G. Needham such a study was commenced at Ithaca in the fall of 1910.

This locality with its many creeks and spring brooks is an excellent collecting ground for Plecoptera, and the equipment of the limnological laboratory of Cornell University makes an intensive study of aquatic forms possible. The essential factor in rearing stone-flies, as in many other stream-inhabiting insects, is running water. This is provided by a series of taps in a roof garden aquarium and also in a small artificial pond out of doors.

Methods. With the hope of obtaining truer results by keeping conditions as natural as possible, most of this study is being carried on out-doors. Some care must be taken in transporting stone-fly nymphs from the stream to permanent quarters. Full grown nymphs can breathe air directly, and have been carried most successfully wrapped in a wet cloth or packed in damp moss. Smaller nymphs can be taken safely for short distances in collecting jars full of clean, cold water.

In the artificial pond the nymphs are kept, eight to ten together, in cylindrical cages made of galvanized wire screen with cheese cloth covers. For small nymphs it is necessary to have the lower part of the cage lined with cloth. The cages are partially submerged in the current near the taps. With flat stones and bits of water weed in the bottom, and a steady flow of water, the nymphs can live a natural life.

The shyness of adult stone-flies makes field observations at close range impossible. Consequently they are kept in screen cages of about two by three feet. Here again an imitation of natural environment is attempted. This is done by keeping green twigs, clumps of sod, stones and pans of water in the cages.

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*Contribution from the Limnological Laboratory of Cornell University.

Although these pans of water are but a poor imitation of streams they suffice for most purposes. Better aerated water is necessary, however, for development of eggs. For this reason they are kept in running water in test-tubes closed at either end with fine silk bolting-cloth.

Nymph.

Habitat. This introductory paper includes only the observations made in June, July and August of the past summer, upon a single species, Perla immarginata. The nymphs occur in moderate numbers in all the larger streams about Ithaca, and very abundantly in the spring brook at Coy Glen. This abundance may be accounted for by the fact that there is less competition for a livelihood in this stream. Perla immarginata reigns supreme at the height of its season, the middle of July, not only as the largest of the stone-flies, but of all the aquatic insects. In the other streams are several competitors of equal size and strength and many more enemies.

Early in the spring, torrents of water rush through the glen, but in July and August the brook is reduced to a shallow stream. The high walls and the narrow, winding course of the gorge shut out so much sun-light that in spite of its shallowness, the water is always cold. Much of the stream bed is shale, free from sand and gravel, but well covered with a diatomaceous ooze. Here the water flows in a thin sheet. In other places are deeper pools strewn with clean, coarse gravel. Stones of all shapes and sizes are scattered along the stream. At this season, most of the stones, even the flat ones on the rocky bed, are partly out of water. Generally these are the haunts of stone-fly nymphs just before emergence.

Neighbors and enemies. These same stones shelter other creatures, fragile may-fly nymphs, chironomid larvae partially concealed in their slime tubes, and caddis worms standing guard behind their seines. Nearby on the rough floor of the stream hang the last stragglers of the mats of black fly larvae. In crevices on all sides lurk cray-fish, less welcome neighbors.

Occurence. Late in June an occasional sprawling, nymphal skin clinging to the upper surface of a stone fortells the approach of the season for Perla immarginata. About three weeks later the casts are very numerous, and the overturning of a single stone sends a whole colony of the tiger-striped nymphs scampering in all directions in search of hiding places.

Length of Nymphal Life. It is evident at a glance that these nymphs are not all of the same size or stage of development. They fall into three groups. One contains very few individuals, these are small immature nymphs not more than half an inch in length. The second group, also a small one, is made up of nymphs about three quarters of an inch long. These are immature too, but older than first, larger and with small wing pads. The mature nymphs with their black wing pads form the largest group.

As far as is known, the complete life-history of no stone-fly has been worked out. Therefore we can only speculate concerning the length of it, knowing of course that whatever it may be, by far the greater part is spent in the nymphal stage. From the brief period of incubation of the eggs of some of the smaller individuals of the group, Capnia for example, and from the appearance of mature nymphs only at the emerging season, it seems probable that the life-history of these is completed in a year. On the other hand, the three groups of nymphs of different size in Perla immarginata and allied species, seem to indicate, as in some of the larger may-flies, a longer period, probably three years. Just where the nymphs live when it is not the transformation season, is not known.

Adaptations. A closer examination of the mature nymph shows that there are no external sexual characters. Nevertheless, the females can be easily separated from the males because the dark brown eggs show through the sides of the abdomen. In addition, as one would expect, the males are smaller; they vary from three quarters of an inch to an inch in length. The females have the same degree of variation, the largest being about an inch and a quarter in length and the smallest a little less than an inch. The color pattern of the nymph, black banded with white or pale yellow, and snowy white tufts of the tracheal gills on the thorax behind and above each leg, would make them rather conspicuous if they lived in the open. (Figs. 3 and 4).

The form of the nymph—flat-bodied, with flat, sprawling legs, and tarsi armed with two strong claws—is strikingly adapted for clinging. The legs are fringed with long hairs, which make them useful in swimming as well as running, and one need only disturb the nymphs to see how swiftly they can escape by either method. The shyness of stone-fly nymphs, their splendid

adaptations for clinging, running and swimming make their existence fairly easy, especially in this stream where the crayfish is the only enemy of any account.

Food Habits. The long standing supposition that stone-fly nymphs devour their weaker neighbors, has been confirmed for this species in a study of their food habits. This has been done by examining the stomach content of nymphs taken from the stream, and also by feeding those in captivity. Dissections of mature nymphs show the alimentary canals empty and in many cases even so collapsed that they are difficult to find at all. Likewise the nymphs kept for rearing refused all food for eight or ten days before transformation.

With growing nymphs it is different; here it is a task to supply them with enough food to prevent their eating one another. In a single day three or four of these nymphs will dispose of a score or more black-fly larvae and half as many small may-fly nymphs. Their greed is brought out even more strikingly by examining the food mounts of nymphs taken from the stream; whole specimens of midge larvae are found not uncommonly and sometimes a may-fly nymph with even the gills intact. The mass of food, however, consists of innumerable shapeless scraps of chitin with scattered fragments of abdomens, setae, antennae, legs; or claws, whole heads, mandibles, maxillae, and labia, making possible the recognition of may-fly and stone-fly nymphs, midge and simulium larvae and pupae.

The only evidence of any herbivorous tendency in this species is the presence of an immense number of diatoms in food amounts. Of course this is a question of direct or indirect eating. One would expect to find diatoms in a food mount made up of pieces of may-fly nymphs and chironomid larvae, and the natural supposition might be that the stone-fly got them second hand. Yet such a statement cannot be made without some hesitation, because the number of diatoms in the mounts seems to increase with a general decrease in the amount of food; and also because diatoms have been found to be the chief food of some of the smaller species of stone-flies.

Transformation. Just before the time of transformation when the nymphs cease eating they become sluggish. And as the time approaches they crawl further and further toward the surface of the water, and finally entirely out of it where they often remain for hours before emergence. The actual

casting of the skin has not been seen in this species. Although adults are rarely absolutely perfect specimens, the percent of individuals lost by inability to complete transformation is exceedingly small. Judging from the fact that no newly emerged insects have been found, it is thought that they must transform during the night, or more probably, in the early hours of the morning.

Adults.

Characteristics. The adult Perla immarginata, (Fig 5), is uniformly dull brown and much less conspicuous than the nymph. As soon as the insect loses its tracheal gills and gains four well developed wings, it is ready for aerial life. Unlike many adults with this equipment, some of the nymphal tendencies are carried over into this stage. Chief among these is the love for hiding. So great is their shyness that, even at the height of the emerging season, the adults are rarely found in the field. Repeated attempts at sweeping the foliage along the stream have met with little success. Careful searching of the rocky walls of the gorge has occasionally revealed an adult hidden away in a crack or crevice. Similar habits have been noticed in the adults kept in cages. They never rest on the twigs but crawl into hiding under the edge of the stones, or pans, or wherever they can wedge themselves into a tight place.

Although they avoid day-light, artificial lights attract them at night. They have been found crawling along poles and fences, or in the road under electric lights in the neighborhood of streams.

When disturbed the adults rarely seek escape by flight, but usually by running. Here again we see a nymphal trait, and a characteristic of the group. They are poor flyers and dependent upon their legs. Some stone-flies do not fly at all, although provided with fully developed wings.

Food Habits. A striking difference between the nymph and adult is found in the structure of the mouth and in the food habits. A character long assigned to stone-flies is rudimentary mouth parts of a biting type. This is true for Perla immarginata, but not for the entire order. In this species we have the reduction of the strong chitinous mandibles to mere fleshy lobes, (Fig. 1). The very appearance of such an apparatus indicates its uselessness, and examination of the

alimentary canal of adults taken in the field, has confirmed this. Water seems much more essential than food for these adults. If ever found out of hiding in their cages, they were almost sure to be on the stones in the pans with their mouths buried in water. Entirely deprived of water, the average length of life is shortened by several days.

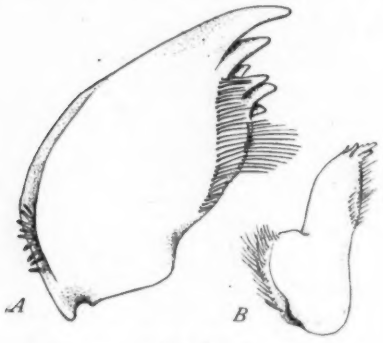


FIG. 1.

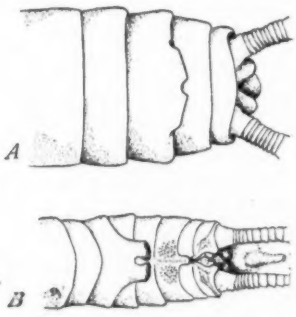


FIG. 2.

FIG. 1.

a. Left mandible of the nymph, inner surface.
b. Left mandible of the adult, same view and magnification.

FIG. 2.

a. Abdomen of the female, ventral view showing the modification of the eighth sternite.
b. Abdomen of the male, dorsal view showing the genital armature with the penis extruded.

Both figures drawn to the same scale.

The voraciousness of the nymphs is necessary, since the adults abstain from food and since enough energy must be stored up to last through aerial life and the completion of the final function, reproduction.

Mating. Ordinarily mating begins soon after emergence. The readiness with which it takes place in captivity has been a great surprise on account of the natural timidity of stone-flies. Frequently pairs have been found in copula in the breeding cages and have been removed to adult quarters without arousing enough alarm to cause their separation. By careful manipulation copulating pairs can even be held in the palm of the hand. This has made a detailed study of mating possible.

Difference in size and external sexual characters make distinguishing the sexes easy. The smallest males measure not more than an inch to the tip of the wings, and the greatest measurement for a female is one and three-fourths inches. In the female the posterior border of the eighth sternite is thickened and slightly emarginate in the middle, (Fig. 2, A). The external sexual appendages of the male, although hidden by the wings, are much more prominent. The fifth tergite is prolonged in the form of a fork extending over the sixth and most of the seventh tergites. The tip of this meets a groove running through the mid dorsal line on the eighth, and surrounded on either side by papillose prominences. The ninth segment is shortened, and the tenth is slightly elongate ending in two strong recurved hooks, (Fig. 2, B).

Just how such an apparatus operated was not obvious at first or even second glance, in fact not until copulation was actually seen. The male rests upon the female grasping her wings and abdomen with the legs of one side, and supporting himself with the legs of the other side. Then bending the end of the abdomen around that of the female, and arching it forward, the male presses close against the female and pulls down the lamina, forcing the recurved hooks up into the vagina. After a few seconds, the male starts a slightly rythmic motion by alternately pulling to and fro. As the motion becomes greater, the hooks are gradually withdrawn, and there is exposed between them a white, fleshy penis resting in the groove and supported toward the tip, by the fork on the fifth tergite. This rythmic motion seems to be pump-like in action. With a quick jerk the recurved hooks are brought up against the fork, an act which causes the contraction of the penis and forces the seminal fluid up into the vagina. The expansion is slower, allowing the penis to become refilled. Undisturbed, copulation usually lasts about forty-five or fifty minutes. Except for microscopic horny papillae on the tip, the penis is entirely fleshy and composed of two telescopic segments. After copulation, it is gradually retracted into the body just below the anal opening, and entirely hidden inside.

Egg-laying. As is commonly known, stone-flies do not deposit their eggs directly, but carry them around for a time in a mass at the end of the abdomen. It is hard to see the reason for this. Apparently it is not to be found in the condition of

the egg itself, for there seems to be no difference between eggs just extruded and those carried for a couple of hours, half a day, or longer. There is a constant regularity in the length of time that elapses between copulation and extrusion of eggs, but not in the length of time eggs are carried. Individuals in the same cage eventually deposit their eggs in the same place, but one may carry them two hours, and another nearly a day under exactly the same conditions.

I am in doubt as to the normal method of depositing eggs. In the field, smaller species, carrying eggs, are often seen on the stones in streams as if they were about to crawl down to the water. And again they appear flying low along the stream and dipping to the surface as if ovipositing. No such observations have been made upon the larger species. The few adults of Perla immarginata which have been seen dropping their eggs in the pans seemed to do it more from accident than from intention. They were crawling around the stones and had floundered into the water. The instant they came in contact with the water the eggs dropped to the bottom of the pan. But many masses of eggs have been found in the pans too far from the edge, or from the stones, for them to have been dropped except from above, or by the individuals having actually crawled into, or on the water.

Concerning the place where the eggs are deposited there is no doubt. When the globular mass touches the water the eggs begin to separate. In the pans they finally settle down into a patch one layer deep, (Fig. 6). Of course this is not the case in the streams where the current scatters them broadcast. They are not tossed about long, however, for as soon as they come in contact with any object they become attached by the glutinous cap which surrounds the micropylar apparatus. These eggs are about half a millimeter long, dark brown in color and oval-shaped. Except for a single circular ridge the chorion is without ornamentation, (Fig. 7).

In following the movement of the different adults from day to day it was necessary to have some means of identifying them as individuals. As has been previously stated, an absolutely perfect adult is rare. Consequently it was a very simple matter to recognize individuals on such characters as a broken antenna or seta, a tarsus minus a segment or two, an imperfect wing, and so on. In this way during the season thirty-two

females and twelve males were kept under close observation. It was soon found that all the eggs were not deposited at one time. A few hours after the first mass was laid, mating occurred again, and within twenty-four hours a second lot had been deposited. Often there was a third mass, and in a few instances a fourth. These followed less rapidly.

As one would expect each successive mass was smaller than the one preceding. A thousand eggs is ample average for a first mass and four masses together would not total over sixteen hundred. It seems likely that a large number of eggs must reach the hatching stage. The chances of fertilization are good since copulation occurs more than once, also if one mass has fallen in an unfavorable place there is a possibility that the others have met with better luck. Yet the number of individuals which reach maturity is comparatively small. A great loss probably occurs during the early nymphal stage when the small white nymphs would be dainty morsels for many a larger creature.

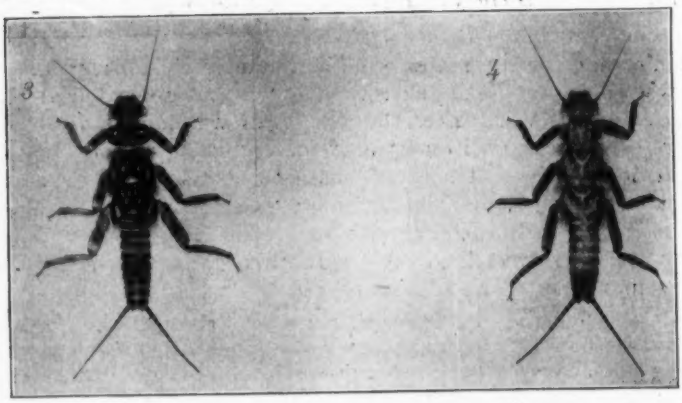
Mating has the usual effect upon the length of life of the adults. When males and females are caged together the average female dies after six or seven days and the male after nine or ten. On the other hand if the sexes are kept apart they live twelve or thirteen days.

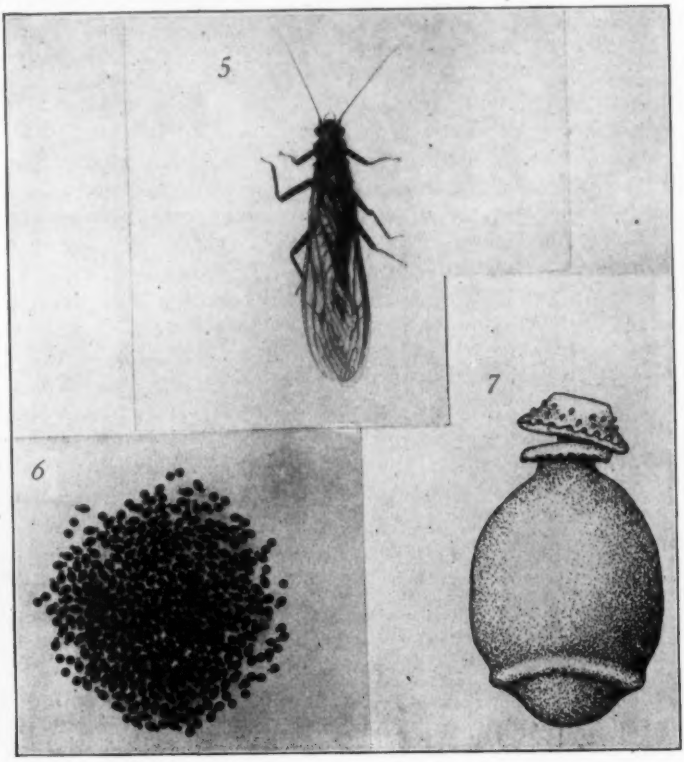
Only a small proportion of the eggs laid in captivity were kept for development. These were easily loosened from the pan with a pipette, removed to the glass tubes and put into running water. They have not yet hatched.

Ordinarily the one great difficulty which has stood out above all others, in attempting to get a complete life history of a stone-fly has been in the handling of the very young nymphs. Although a variety of methods have been tried, nymphs have not been kept alive for longer than ten days. Whether this is due to lack of proper environment, the right kind of food, or both, can not be said. The only possibility of tracing the life-cycle of a stone-fly, from egg to adult, seems to hinge upon a more complete knowledge of the early nymphal life.

PLATE XXIII.

Fig. 3. Dorsal view of the nymph, natural size.
Fig. 4. Ventral view of the nymph, natural size.
Fig. 5. Adult female, natural size.
Fig. 6. Mass of eggs, about 4 times natural size.
Fig. 7. A single egg, greatly enlarged.





Lucy M. Smith.

THE LIFE-HISTORY OF A BEE-FLY (SPOGOSTYLUM ANALE SAY) PARASITE OF THE LARVA OF A TIGER BEETLE (CICINDELA SCUTELLARIS SAY VAR. LECONTEI HALD.).

By VICTOR E. SHELFORD.

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I. INTRODUCTION.

The life histories of the American Bombyliidæ are imperfectly known and this lack of knowledge is due largely to the difficulty of studying parasitic forms. The species in question is never abundant and consequently much time has been consumed in getting together the data for the account here presented. Near Chicago it occurs on dry sandy places where there is much vegetation and where the sand is slightly blackened with humus. The data presented were collected mainly in connection with work upon the host which involved collecting and rearing to maturity about a thousand host larvæ.

The larva of the parasite was first discovered in 1904 but none was successfully reared until 1906; the method of egg laying was not successfully observed until 1908 and 1909 while attempts to study the adult habits in 1910 and 1911 were only partially successful.

LIFE HISTORY OF THE HOST.

Cicindela scutellaris Say *var. Lecontei* Hald. is found in areas of dry sand to which considerable humus has been added by decaying vegetation (Wickham '02, Shelford '07, '11). Adults are present near Chicago from April to June and again in September. The fall individuals are those emerging from the pupal stage and are not sexually mature. These individuals pass the winter in the ground, become sexually mature after the warm days in April and deposit eggs in May and early June.

The young larvæ appear in late May and early June. The larvæ live in vertical burrows which end at the surface in a smooth circular opening (Fig. 2; also bh of Fig. 16, p. 221). They pass through three instars, the first two of which are about one month each in duration. The third and last stage is reached in the last part of July, in August and early September. These stages pass the winter in the burrows, appearing at the surface in May, and feeding until from June 20 to July 20. Each larva then digs a pupal (pch of Fig. 16, p. 221) burrow filling the main burrow at the same time. The larva remains quiet in this cavity for about three weeks when it pupates if it has not been parasitized, and emerges in August, making its way to the surface about three weeks later.

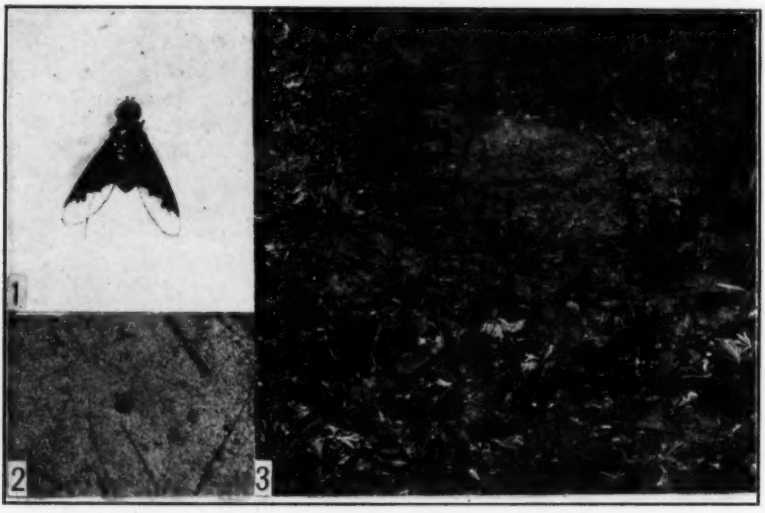


Fig. 1. The adult fly about twice natural size.
Fig. 2. A burrow of a larva of the second instar of *C. scutellaris Lecontei*, about natural size.
Fig. 3. General habitat of *C. scutellaris Lecontei* at a point where the fly was observed ovipositing, and the kind of situation in which the parasite is most abundant. The burrows of two larvæ of the host are in the last instar, and are visible above the small arrows.

II. Life History of the Parasite (*Spogostylum*).

1. Adult Habits.

The adult is a bright shiny velvet black fly with the basal two thirds of the wings black and the distal third transparent. (Fig. 1). It occurs in July and August, in open spots on sandy soil, especially in the kinds of situation shown in Fig. 3, where herbaceous vegetation and flowers are numerous. It is commonly associated with other bee flies such as *Anthrax impiger* Coq., *Anthrax fulvohirta* Weid., and *Anthrax molitor* Loew. which are much more abundant and often visit flowers in numbers, also *Exoprosopa*, which probably lays in the burrows of the *Bembecid* wasps. The habits of the male *Spogostylum* have not been observed. The female usually alights near the ground on the lowest plants or on sticks and leaves. In sunny weather she starts with remarkable swiftness when a shadow is passed over her but appears not to be stimulated by the presence of the observer under other conditions. In cloudy weather the writer has shaken an insect net within a few inches of one of the flies without causing her to move. The food habits have not been observed but a single individual lapped sugar and water from a piece of paper, while in captivity.

2. Egg Laying.

The female flies about two inches above the clear open sand in an irregular somewhat zig-zag fashion until apparently by chance its eyes pass above a hole in the sand, (Figs. 2 and 3). When this happens, the fly suddenly halts and moves backward and downward in a curved course. At the same time the abdomen is thrust forward so that it touches the surface of the sand at a point 5 to 10 mm. from the edge of the hole. The impact of the abdomen upon the sand is sufficient to perceptibly move small particles, some of which appear to fall in the burrow. The thrusts are usually repeated a number of times. After each movement, the fly returns to approximately the position at which the thrust began. The sight of the hole below the eyes acts as a trigger which sets off the thrusting reflex. The host larvæ frequently rest in the burrow some distance below the surface. On two occasions the fly stopped thrusting when the larva appeared near the surface. The size and shape of the hole appear not to be of prime importance.

Burrows of the second instar of *Cicindela* are most frequently visited. This is probably due to the fact that these holes are most abundant. The burrows of young spiders (*Geolycosa*) which have a web around the opening, are not rejected while holes of the first and third instars of *Cicindela* as well as partially covered holes produce the reaction at least once. General results of one observation are shown in table I.

TABLE I.

A Seven Minute Observation of the Egg Laying Reaction of a Female *Spogostylum*, July 16, 10:30 a. m.

Hole Producing Reflex	Stage	No. of Thrusts	Remarks
Burrow of— C. Lecontei	2 d.	7	Larva appeared.
Geolycosa	young	3–5	Web surrounding opening.
Large nondescript hole	...	...	Rejected after halt without thrust
Burrow of— C. Lecontei	2 d.	6	Stick half covering hole.
C. Lecontei	2 d.	2	Burrow less than one cm. deep due to closing near surface; probably during moult.
C. Lecontei	1st	2	
C. Lecontei	2 d.	5	Stick across hole.
C. Lecontei	3 d.	3–5	Partially covered.

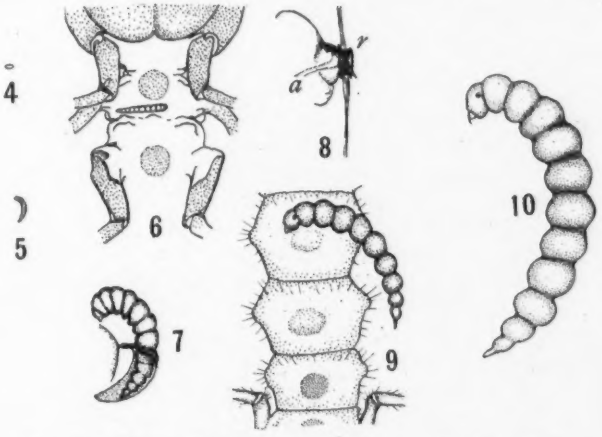
A summary of the observation of egg laying is as follows: Egg laying thrusts were executed, by two individuals observed, before holes as follows: One first larval stage of the host, eighteen second larval stages including one partially covered with a stick, and a shallow one (filled below the surface); one third stage of Cicindela, one small spider hole. One large nondescript hole arrested the flight but did not produce the egg laying thrust.

3. *Egg*, (*Fig. 4*).

A female taken while laying was found to contain a very large number of eggs, which could be squeezed out by a gentle pressure upon the abdomen. The eggs are light brown ellipsoids .28 mm. by .12 mm. They are not adhesive.

4. *Larva* (*Fig. 5*).

Young larvæ are most commonly found singly on the ventral side of the thorax of host larvæ of the third instar, where they cling between the legs. No second instars have been found with parasites. While in the position between the legs they cannot be reached by the host and do not come readily into contact with the sides of its burrow. There are however frequent exceptions to this, for host larvæ not infrequently have more than one larva between the legs or single larvæ on other parts of the body. One host larva had in addition to the parasite on the ventral side of the throax, two others on the posterior third of the abdomen. Attempts to secure eggs or young larvæ from sand gathered from the edges of burrows about which eggs had been laid or to rear larva from eggs squeezed from a laying female, have failed. Neither have we



Figures 4–10. Early larval stages of *Spogostylum anale* Say.

Fig. 4. The egg; enlarged about five diameters.
Fig. 5. A young larva of the second stage; about five times natural size, in a somehwat curved position.
Fig. 6. The same in position enlarged about nine times.
Fig. 7. At the time of moving to the abdomen; enlarged about five times. The larva has withdrawn its anterior half from the old integument.
Fig. 8. The larva in position in the thorax, showing the ring of thickened chitin(r) in the integument of the host and the long slender mandibles in position.
Fig. 9. The larva after one day on the abdomen of the host: about five times natural size.
Fig. 10. The larva at the end of the second day upon the abdomen.

discovered how the larva reaches the body of the host. The host larva with the three parasites was placed in a tube of sand one inch in diameter together with two other host larvæ, one bearing two parasites and the other uninfested. The double and triple infested hosts died leaving five parasitic larvæ in the tube with the one live host larva. *None* of the parasites *reached the host larva.* Host larvæ dug from the point where a female fly was seen to deposit eggs on July 16 had parasites of the first and second instars on the ventral thorax when removed from their burrows Sept. 23d. About 7 percent of the host larvae are parasitized. While some catches of fifty host larvae were as high as 16 percent infested others were quite free from parasites. This is particularly true in the pine area (see p. 222), where only one out of several hundred host larvae were parasitized.

The structure of the larva was but little studied on account of lack of material. The head segment bears the usual mandibles, which are long and curved. They pierce the integument of the host obliquely; a ring of thickened chitin develops about them and the mouth is brought into contact with the center of the ring and thus with the tissues and fluids of the body (Fig. 8). The number of larval moults has not been fully determined and the following account is not necessarily accurate. The smallest larvæ found are from 0.5 to 0.6 mm. in length and are evidently in the first instar. These were taken in late summer and autumn and occasionally in spring. Most of these larvæ moult in the fall; all pass the winter attached to the body of the host, those of the first stage moulting in early May. When the larva moults, the integument splits in the region of the thorax. The anterior end of the body is withdrawn from the old skeletal parts, leaving the old mandibular skeleton imbedded in the host. The posterior part of the larva apparently remains in the old integument until the new integument of the head region is hardened when a new attachment to the host is affected. When again attached, the larva withdraws the abdomen from the exuvium (Figs. 5, 6 and 7).

The larvæ of the second instar, (length 1.2 to 1.6 mm.), probably moult again after the host has fed about a month (early June), but this is not certain because exact measurements could not be made of the small living larvæ while attached to the host and they could not be removed without killing them.

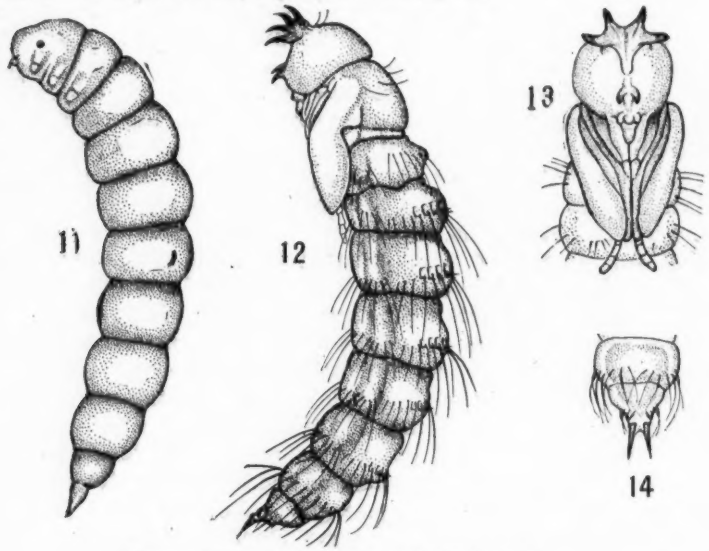
A third moult takes place about the time the host stops feeding (late June), but in the cases observed, before the pupal cell is constructed. This moult clearly takes place but the larva again could not be accurately measured.

In late June the host constructs the pupal cell (*pch of Fig. 16, p 221*) and becomes relatively inactive but does not normally pupate for a month. The parasite does not grow rapidly until the host has been in the pupal cell for about three weeks. By this time the old organs of the host have for the most part, broken down and the internal parts are in a semifluid condition. The parasitic larva now moults again and this time leaves its former position completely. In the four or five cases observed it moved to about the middle of the ventral side of the host, (Fig. 9). It will be noted that at the time of the previous moults of the parasite the host was active and if the larvæ had completely released its hold at any of these times the result would probably have been its own destruction. At the time of this fourth moult, on the other hand, the host is almost unable to move. Immediately upon securing the new source of food through the abdomen of the host the parasite begins to grow more rapidly and more than doubles its length in 48 hours. The length at the time of the fourth moult is about 4.5 mm.; after 24 hours the length is 6.5 mm. (Fig. 9), and during the next 24 hours the larva reaches a length of 1 cm. (Fig. 10), which is two-thirds the length of the abdomen of the host. At the end of 144 hours the parasitic larva is full grown (Fig. 11). The length is now 1.8 cm. and all of the later rapid growth has apparently taken place without further moulting. The full grown larva passes six or seven days in the pupal cavity of the host in a quiescent stage before the pupal moult occurs.

5. Pupa and Adult.

The pupa is of the type common among the diptera. There are four curved hooks upon the anterior side of the head united at the base in the form of a fan (Figs. 12 and 13). Two smaller hooks on the ventral side of the head appear to correspond in position to the antennæ. There is a circle of long stiff bristles on each segment of the abdomen together with U shaped bristles on the dorsal side. The pupa upon emerging is unpigmented; the hooks on the head become dark in about five days; the head becomes light brown in nine days and dark

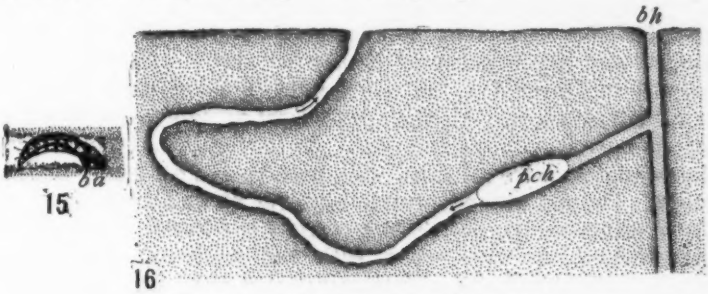
brown in thirteen days; pigment appears in the wings at the end of thirteen days in the center of the segments of the abdomen in two weeks. Pigmentation is apparently complete in about sixteen to eighteen days (July 13 to Aug. 3).



Figures 11–14. Late larvæ and pupal stages.
Fig. 11. Full grown larva showing the leg buds; enlarged five times.
Fig. 12. Side view of the pupa; enlarged five times.
Fig. 13. Front view of the anterior end of a fly pupa.
Fig. 14. Front view of the posterior end of the same.

Some time soon after the pigment is completely developed, the pupa begins to use the hooks for digging. In this process the numerous long stiff bristles arranged in a ring about the segments and projecting backward are of much importance for they tend to make simple movements either push the body forward or push loose sand backward. The large U-shaped bristles along the dorsal side may or may not function in this way also. The main digging operations are carried on by means of the hooks on the head. The two spines of the posterior end serve as anchoring organs. The body is curved dorsalward in the form of a bow with the dorsal side pressed against the upper side of the burrow. The U-shaped bristles prominent upon the dorsal side may function as anchors in this

operation. The two posterior spines are thrust into the floor of the burrow and the curvature is increased, which cause the head to move back as shown in Fig. 15. After a number of hoeing movements, the pupa usually wriggles backward carrying the sand with it by means of the bristles and again wriggles forward until the head is in contact with the end of the burrow. The hoeing movement is repeated or less frequently the body is rotated, the hooks serving as a boring organ.



Figures 15–16. Emergence from the ground.

Fig. 15. Diagram showing the movement of the pupa in digging its way out of the ground. Natural size (a).

Fig. 16. Showing the burrow and pupal cell of the host with the path dug by the pupa of Spogostylum.

The boring movement was observed in the case of one individual, the host of which had been confined in a glass tube eight inches long and one and one-half inches in diameter. The burrow and pupal cell of the host were constructed in contact with the glass. Much of the life history of one parasite was thus observed. The digging of the parasite pupa began at night, and was not noted until the middle of the next forenoon (July 15), [began in pch of Fig. 16, p. 221]. During the last eight hours the larva progressed at the rate of 1 cm. per hour. It moved in contact with the glass and traveled more than once around the tube just inside the glass. The total distance through which the parasite dug was about 24 cm. Apparently immediately upon reaching the surface the fly emerged. It left the pupal integument sticking in the burrow. The emergence of the fly was not observed as the last centimeter of digging was accomplished in less than 20 minutes and the fly emerged between observations. The adult was found resting on a small blade of grass near the hole. This adult lived only about two days.

A pupa removed to a watch glass with the bottom covered with moist filter paper executed the digging movements for a day or more, but failed to emerge. One reared in a very small amount of sand and between two glass plates dug to the surface and then back into the sand again. It emerged in imperfect condition within the sand.

III. Other Species.

Work on the European species of the family Bombyliidæ is also far from extensive. Dufour gave an account of the larvæ, pupæ, and adult habit of *Bombylius major*. He found this species in March 1857 on the sloping banks of sand hills with southern exposure. He saw the fly light quickly at the openings of the burrows of Hymenoptera. In the locality, the burrowing hymenoptera were principally Andrenidæ and especially *Colletes hirta*. Dufour was never able however to find the egg of the fly. Williston '08, p. 213, summarizes the known hosts of the Bombylidæ. In connection with the study of *Spogostylum anale* (July 30), *Anthrox impiger* was seen resting on the ground touching the abdomen to the surface of the sand. *Anthrax impiger* Coq. (July 16–30), lights on blossoms of horse mint, etc. or rests on other objects on the ground. Two, a pair, of *Exoprosopa fascipennis* Say were taken while flitting before a burrow of *Microbembex monodonta*.

IV. Ecological and Geographic Distribution.

1. Ecological Distribution of Parasite and Host.

Near Chicago, the fly larvæ appear to be confined to *C. Lecontei*. One or two larvæ of *C. hirticollis* which do not occur with those of *C. Lecontei* were found to bear similar parasites. Adults of *Spogostylum* have never been seen near the *C. hirticollis* habitat. *C. purpurea limbalis* which lives on steep clay bluffs is parasitized by a larvæ somewhat different from that of *Spogostylum*.

In 1907 and 1912 I pointed out that the development of vegetation upon the sand areas at the head of Lake Michigan takes places in an orderly fashion. Cottonwoods are the pioneers and are accompanied by *Cicindela lepida*. Only one *Spogostylum anale* Say has been seen in these localities and this when a strong wind was blowing from a more favorable habitat. The cottonwoods are succeeded by pines and *Spogostylum* is rare among them. *Cicindela formosa generosa* occurs in the

mixed pine and cottonwood areas but none of these have been found with parasites. The large pit and goose-neck burrow probably prevent this species from serving as a host (Shelford, '08). Very few parasitized *Cicindela Leconti* larvæ have been taken here though the host is only a little less abundant than in the oak area. It is on the margins of the depressions in the pine areas that the larvæ of *C. tranquebarica* Hbst. are numerous (Shelford '07) but none of those of this species were found parasitized, though the number of larvæ dug was great.

Spogostylum anale and its host species are most abundant in the early stages of the black oak forest where cacti occur (Fig. 3). The exact landscape aspect is significant only as an index of the physicial conditions. The evaporation in these open oak forests is about one half that of the cottonwood area and less than that of the pine area. The available soil moisture is less (Shelford, '12).

2. Geographic Distribution.

American dipterologists have kindly supplied me with data on the distribution of *Spogostylum anale* as follows:

Prof. D. W. Coquillett: Sandy Hook, N. J.; Indiana; Carbondale, Ill.; Mississippi; British Columbia; Washington; Mesilla, N. M.; St. Louis, Mo.; Shreveport, La.; Georgia; Enterprise, Fla.; Cambridge, Mass.

Dr. J. S. Hine: Mission, British Columbia; Onaga, Kansas; Akron, Ohio; Cincinnati, Ohio.

Dr. C. T. Brues: Douglas Co., Kansas; Crete, Nebr.; Austin, Texas.

Dr. C. F. Adams: Jackson Co., Mo.; Lawrence, Kan.; Clark Co., Kan.; Fayetteville, Ark.

Prof. E. P. Felt: South Britian, Conn.; Albany, N. Y.

Prof. J. H. Comstock: Manlius, N. Y.

Dr. A. L. Meander: Galveston, Texas; Golden, Colo.

Map (Fig. 17) shows the distribution area of the host (A) generously represented by connecting the more remote localities along nearly direct lines where suitable habitats are known to occur. The distribution of the parasite is wider than that of the host species including all varieties extending into Mexico and along the Pacific coast. Accordingly the parasite must use another host. Several other species of the tiger beetles may no doubt serve this purpose.

Some of the flies reared in a hot green house lacked the white hairs along the abdomen, which characterize the species. Prof. Williston tells me that these hairs were absent from specimens taken in Mexico and doubtfully referred to this species by Osten Sacken.

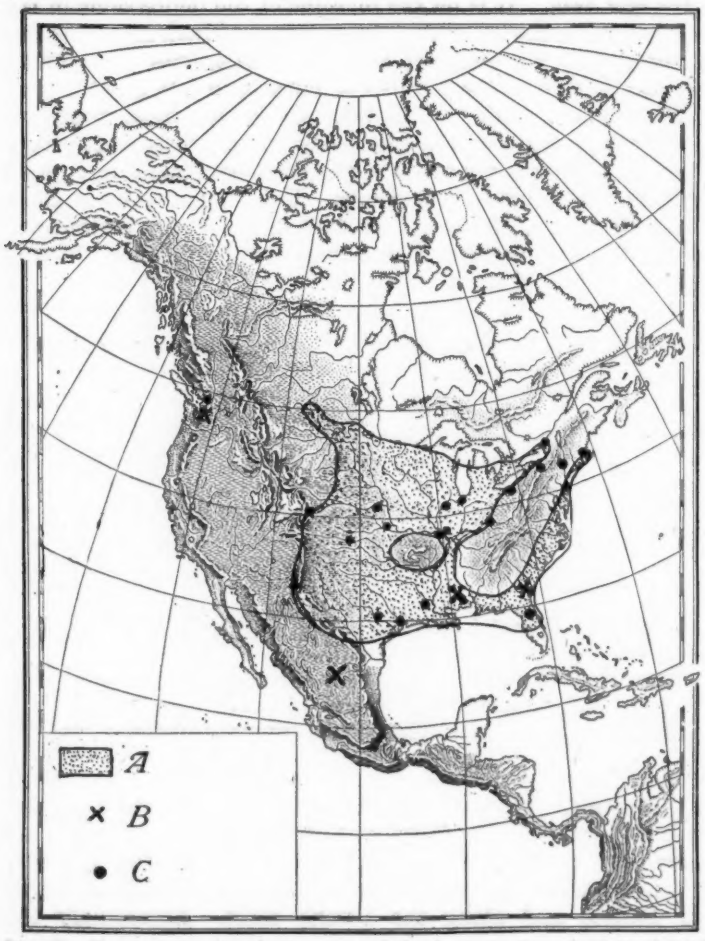


Fig. 17. Showing the distribution area of the host species. (A of the legend.) The area blocked out is generous including all the probable territory. The crosses (B of the legend) represent state and country records. The round dots (C of the legend) represent some of the definite localities from which the fly has been recorded.

V. Summary.

1. The adult fly deposits eggs at the edge of circular openings in sand. In the areas inhabited by the flies (near Chicago) these openings are usually the larval burrows of *C. scutellaris Lecontei* Hald. p 215.

2. The sight of the burrow opening, beneath the eyes appears to call forth the egg laying reflex, p. 215.

3. The larvæ live as ectoparasites upon the tiger beetle larvæ for a little less than one year, growing slowly and moulting several times, p. 217.

4. When the host is ready to pupate, the larva moults, moves to the abdomen and grows to adult size in about six days, p. 219.

5. When the pupa is fully mature it digs out by means of hooks on its head and backward projecting bristles on the abdomen. The digging is sometimes downward for a time and lasts for more than 24 hours, p. 221.

6. The parasite is more widely distributed than its host, p. 223.

VI. Acknowledgments and Bibliography.

The writer is indebted to Dr. S. W. Williston and Mr. C. A. Hart for the identification of the Bombyliidæ, and to the gentlemen named above for the distribution records.

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A NEW APPLICATION OF TAXONOMIC PRINCIPLES.

By CHARLES H. T. TOWNSEND, Lima, Peru.

Scarcely more than half a century has passed since the belief was generally entertained as indisputable that species and other taxonomic categories were fixed and unchangeable entities. The basic elements of current taxonomy date a century farther back.

Our taxonomic system was founded on the principle of permanency in organic morphology, without any idea of change and evolution. In its original concept and application it was therefore inelastic and not in accord with the facts. We have been constantly endeavoring, however, to apply this inelastic system to the elastic morphology of living matter. The result is a demonstration of incompatibility between the two.

Any taxonomic system must be arbitrary and fixed in certain of its fundamental aspects, but it must also accord with phylogenetic facts. A radically new system is not here proposed, but merely a modification of the current system to fit the phylogenetic facts that we find today. It is not held that living matter is morphologically changing with such rapidity that it needs a system which will change within a lifetime in order to keep up with the progress of evolution. But it is held that living forms exhibit distinct phylogenetic phases according to the age of the stocks of which they form a part, and that this fact must be taken into account in their taxonomic treatment.

No stock is today changing rapidly enough in nature for us to note the specific steps of change. But if we pass all stocks in phylogenetic review we are struck most forcibly with the successive but gradual change of conditions exhibited as we proceed from the oldest to the youngest stocks. In such review we get an instantaneous reflection of the bimorphologic changes which take place in time.

It has fallen to the lot of the writer to make a critical study of the morphology and phylogeny of the muscoid flies, which undoubtedly comprise some of the youngest stocks of insects, and to attempt to establish a taxonomic treatment of them which shall accord with their morphology and phylogeny and

thus prove satisfactory from all practical points of view. In this task difficulties have been encountered which can only be surmounted by conforming to lines of logical simplicity. Phylogenetic facts can not be changed. The logical alternative is to change our pseudophylogenetic plan of taxonomy to a phylogenetic one.

The history of muscoid taxonomy furnishes a vivid illustration of the necessity for such change. The chronologic alternation between splitting and lumping has been constant, but always gradually tending toward greater radicalism in the former. Brauer and Bergenstamm were the first students of the superfamily to recognize the difference in phylogenetic conditions existing here and to put the idea into words. Their system of taxonomy shows that they approached much nearer to the truths of phylogeny than had any former students of the group, but they failed in many cases to grasp the relationships because they had no uniformly true criterion thereto in the external adult anatomy. It has been left for students since their time to discover criteria in the reproductive system and early stages that furnish unmistakable clues to these relationships.

It was the good fortune of the writer to figure largely in the last named investigations, and therefore to obtain facts which constitute a definite basis for phylogenetic deductions. Once such deductions are authoritative—recognized as unmistakably founded on fact—we are able to proceed with confidence in the separation of forms of diverse origin, however similar may be their external morphology. This process brings us face to face with phylogenetic facts that could never before be confidently accepted, and with many which were never before suspected to exist. It compels us to draw lines where such were never before imagined, and it emphasizes with extreme force the shortcomings of current taxonomy if applied to young stocks.

The writer claims in this connection nothing more than a clear view and conscientious record of what has come within his range of vision. The privilege of applying a phylogenetic key to the taxonomy of some of the youngest and most obscurely differentiated groups of insects has been his, and it has furnished him an insight into the relationships of these groups and into the taxonomic needs of young stocks in general that was only

dimly comprehended before. The one who uses this key conscientiously and with fair judgment must get this insight. It only remains to bring the taxonomy into accord with the conditions. This is no simple matter, but it is capable of adjustment.

A careful comparative study of muscoid conditions by the writer, extending over the past five or six years and beginning before the reproductive and early-stage criteria became available has resulted in what may be called the typic-atypic application of taxonomic principles. The idea was dimly comprehended in 1907 from a study of the external adult anatomy alone and published in May, 1908 (Tax. Musd. Flies), while a clearer perception of it was gained and the foundation for its practical application laid during the next few months and the results published in September, 1908 (Rec. Res. from Rear. and Dis. Tach.). From that time to the present the typic-atypic idea in taxonomy has kept pace with the progress of the investigations into the reproductive and early-stage characters of the muscoid flies as compared with their external adult morphology. The working out of the scheme of application with the view of ultimately bringing it to a point of completeness has been laborious in the extreme, and many mistakes and new starts have been made. Theoretical phylogeny and a taxonomic application to match have been constantly checked up by practical and actual phylogeny, thus showing errors that have had to be corrected.

The writer has been still further fortunate in being able to spend some time during the past three years, 1910 to 1912, in several districts of the Andean montanya in Peru and Ecuador, perhaps the most favored biotic region on earth and thus the best adapted to illustrate the working out of phylogenetic principles in nature. Here he has been tremendously impressed with the extreme richness in transitional forms displayed by certain of the youngest muscoid stocks, which have furnished additional proofs of the soundness of the typic-atypic system of treatment. A paper on these forms is forthcoming (New Gen. and Spp. Musc. Flies, chiefly Hystriciidæ from the And. Montanya).

The typic-atypic system calls into use the new group-unit category, which includes the typic genus and such atypic genera as approach more closely to it than to any other typic

genus. It has gradually become evident that this category is a natural prime division of the subtribe, demanded in young stocks where transitional forms are numerously present but not as a rule called for in older stocks where such transitionals are infrequent.

It may be pointed out by way of illustration that we know many insect stocks whose component forms are well differentiated from each other; we know other insect stocks whose forms are less markedly differentiated among themselves, and we know still further stocks which comprise masses of closely similar forms. The first are old stocks, the second are middle-aged stocks practically in their prime; the last are young stocks, still undergoing evolution and characterized by the presence of many transitional forms. The same system of taxonomy is not applicable to all these classes of stocks. The three classes mentioned are of course not clearly delimited, for certain stocks are bound to be intermediate between them. But each stock can always be treated on its own merits. For the first class in general, the current system of taxonomy answers fairly well—that is to say, the tribes are usually quite easily divided directly into genera. In the second class, comprising in general the stocks of middle age, we need the subtribal category between the tribe and the genus. In the youngest stocks we need to employ still another category, as an elementary grouping of genera, between the subtribe and the genus. This is what has been termed the group-unit, for it is both theoretically and practically the unit of taxonomic groups.

So far as it has been possible to work out the status of the group-unit to date, its value appears to correspond to a fractional part of the contracted subtribal value and the whole or a part of the transitional subtribal value, as these values are exhibited in young superfamilies and stocks undergoing evolution. The group-unit therefore corresponds to the well marked genus in the old stocks, plus its intergeneric space which is conceived to be a fixed quantity covering certain transitionals that have dropped out. The well marked genus itself corresponds to the typic genus of the group-unit, while the latter has associated with it various transitional or atypic genera which are not represented in the old stocks but must here be fitted into the taxonomic system. These transitionals or atypic genera are not subgenera of the typic genus. They are subordinated to

the latter only in consensus of characters and not in value. They correspond to the intergeneric space that belongs with the well marked genus in the old stocks, but which forms no integral part of it. The writer has considered well the possibility of interpreting the group-unit, as here constituted, to be the natural genus, and thus of doing away with the necessity for the name group-unit by employing the subgeneric category instead of the generic for the group-unit's prime divisions. This plan has proved not to be practicable. Subgeneric divisions may often be recognized within the typic genus, and sometimes in the atypic genera, so neither can be considered subgenera. In the sum of their characters the typic and atypic genera are too distinct from each other to be considered as mere ill-defined groups of species under a genus embracing all the forms in the group-unit. Genera are prominently distinguishable groups of species, and the atypic as well as the typic genera fit the definition. Furthermore, in the young stocks there are inter-subtribal groups of transitionals which come between the subtribes proper or typic subtribes, and which may be termed transitional or atypic subtribal groups. The group-unit is capable of representing in their true relationships and thus accomodating in the taxonomic system these transitional subtribal forms, which do not occur in the old stocks and can not be fitted into the system of taxonomy commonly applied thereto.

Attention must be drawn to the fact that stocks become fixed, and thus easily amenable to delimitation on the old plan, only when their evolution is completed. The lives of stocks and groups of stocks may well be likened to the lives of individuals. They differ in extending over far greater periods of time, which is only a relative difference. Like individuals, they spring from small and embryonic beginnings, are launched upon the outer world, gradually grow, unfold, develop, pass through various stages of change and specialization, in time reach their zenith and cease evolution, finally wane, become senile and eventually extinct. Waning and senile stocks and all those that have ceased evolution, that is to say fully matured stocks, are easily defined because few or no transitionals are present to hinder definition. But stocks that have not yet reached their zenith, that is to say adolescent stocks, are filled

with transitionals and hence their component categories are difficult of delimitation.

These facts and the consequent necessity for a fractional subtribal category must be apparent to anyone who studies these flies assiduously. In many cases the natural tribes and subtribes can not be defined on the external characters of the adult, nor can they be defined in other than a very complex and thus highly unsatisfactory manner on all characters, due to the presence of the transitionals, and we are thus forced to employ more restricted group categories in order to make a taxonomic system fit them. The conditions which we face here are those that obtain at any given time during the active evolution of new and young stocks. If we had all the individuals that have been produced during the evolution of any subtribe of insects, arranged before us in the order of their descent, we would be totally unable to classify them into either group-units, genera, subgenera or species, simply because no lines of division would be indicated for such separations. They would be found to form a mass of transitionals in a gradual and spreading transition from first to last; through their roots all would be found to connect by gradual transitions with each other. But at any given point in their development by excluding their predecessors,the remnant would be amenable to separation into categories after the group unit plan. These conditions actually obtain in certain young stocks today, and it is only due to the fragmentary nature of the material which we are able to secure out of their totals of countless individuals produced that we are able to attempt a classification of the residue. We do not have to fit their predecessors into the taxonomic system, since they are all lost to us except recent material which agrees with the present. Therefore we are able to draw lines of separation, but the transitionals present demand that the lines be drawn closely. Here lies the necessity for the group-unit category. Its province is to represent the transitional subtribal forms in their true relationships to the typical divisions of the subtribe proper, in young and new stocks now undergoing evolution.

The term group-unit was chosen because the value of the category to which it is applied is bound to be the unit of group values. Species and genera are both taxonomic units, since both enter into the concept and construction of the binomial.

The elemental combinations of genera must thus constitute the units of group formations and values. It is proposed that the name of the group-unit be formed by adding *iæ* to the root of the name of its typic genus. This does not conflict with any of the group endings established by the International Code and by general usage.

The group-unit permits us to arrange with phylogenetic fidelity the components of stocks whose transitionals are largely present, fitting all into a natural taxonomic system. There can be not the slightest doubt that this category is an absolute necessity to the clear and concise taxonomic handling of the forms that comprise the youngest stocks. The further details of the new application of taxonomic principles here outlined largely remain to be worked out. This must be done by applying the principles to the young stocks themselves as they exist today.

A STUDY IN ANTENNAL VARIATION.*

By Edith M. Patch.

PLATES XXIV–XXVII.

During the summer and fall of 1912 annulation counts of 1243 antennae of *Schizoneura* developing on *Ulmus* (leaf and bark), and *Pyrus* and *Crataegus* (bark) were made by Mr. William C. Woods and the writer of this paper.

A detailed record of the annular sensoria present on each of joints III, IV, and V of every antenna counted, giving a tabulation of 3729 counts in all, is preserved on file at the Maine Agricultural Experiment Station and a copy of this record will be lent upon request to any one making a particular study of the species concerned. The counts in tabular form are too bulky to be conveniently printed as they stand; and as nearly 100 curves would be necessary to cover the various collections adequately that method of presentation was also rejected for the time though part of the data may be reduced to this form later.

The drawings of the 90 antennae selected show, however, the most significant ranges of variation and give in themselves a summary sufficient for most purposes. The antennae are all drawn to the same scale with particular reference to the number of annulations present on each of the joints III to V and where of interest also of joint VI; and the length of each joint. No especial attention has been paid to other antennal details and the drawings are not to be considered a study of the terminal joint except in the two respects indicated. In some instances the drawings were made from mounts in which the antenna was curved on the slide and an arbitrary correction of this for the purpose of getting approximately straight drawings for plates, gives the peculiar irregularity in contour apparent.

Frequent examples of freak antenna in which two joints were apparently merged were met and some of these are represented by Figs. 32–36 and Fig. 82.

Appreciative thanks are due to several widely scattered entomologists for their kindness in sending material from different localities, who are, in part, acknowledged in the collection data which follow.

*Papers from the Maine Agricultural Experiment Station: Entomology No. 62.

History of Collections Tabulated.

39–04. (Fig. 74). Elm rosette. Orono, Me. June 15, 1904.

6–05. (Fig. 90). Mixed collection from elm leaf roll and rosette. Orono. June 16, 1905.

95–06. (Figs. 19–21). Elm bark. Orono, Aug. 4, 1906.

114–06. (Fig. 29). Crataegus bark. Maine. Sept. 17, 1906.

115–06. (Figs. 30–31). Apple bark. Maine. Sept. 17, 1906.

7–08. (Fig. 22). Elm bark. Orono. June 16, 1908.

50–09. (Figs. 14–18). Elm leaf collection. Brewer, Me. July 1, 1909.

63–11. (Figs. 23–26). *Pyrus* sp. bark. (cultivated variety of mountain ash). Orono. Aug. 28, 1911.

64–11. *Pyrus sitchensis* (Roem) Piper, bark. Orono. Aug. 29, 1911.

6–12. (Fig. 13). Elm leaf roll. Alabama. Received May 6, 1912. Progeny of this collection lived for a fortnight on apple seedlings.

9–12. (Fig.11). Elm leaf roll. Columbia, Mo. Received May 12, 1912, from Dr. L. Haseman. The winged progenitors of 9–12. Sub. 1. (Fig. 27) which were reared in the laboratory on apple seedlings. A fuller account of this collection is given in Bulletin 203 of the Maine Agricultural Experiment Station.

9–12. Sub. 1. (Fig. 27). Apple seedling. Laboratory bred. Sept. 20, 1913. The progeny of 9–12 which see for discussion.

11–12. (Fig. 12). Elm leaf roll. Knoxville, Tenn. Received May 20, from Dr. Gordon Bentley. Progeny of this collection were reared on apple seedlings from May 20 to June 26.

12–12. (Fig 10). Elm leaf roll. Marion, S. C. Received May 28, 1912, from Mr. W. A. Thomas.

21–12. (Fig. 89). Mixed collection from elm leaf roll and rosette. St. Louis, Mo. Received June 3, 1912, from Mr. J. T. Monell.

29–12. Elm rosette. Orono. June 6, 1912.

30–12. (Figs. 83–88). Elm leaf roll. Marion, S. C. Received June 8, 1912, from Mr. W. A. Thomas.

35–12. (Figs 8 and 9). Elm leaf roll. St. Louis, Mo. Received from Mr. J. T. Monell, June 14, 1912.

43–12. (Fig. 2). Elm leaf roll. Orono. June 20. For discussion see 113–12.

45–12. (Fig 68). Elm rosette. Calais, Me. June 21, 1912.

49–12. (Figs. 76–82). Elm rosette. Standish, Me. June 24, 1912. The rosette was old and considerably dried and the migrants were smaller than those from fresher and juicier rosettes.

53–12. (Figs. 3 and 4). Elm leaf roll. Orono. June 26, 1912.

57–12. (Fig. 69). Elm rosette. Caribou, Me. June 26, 1912.

58–12. (Fig. 75). Elm rosette. Berlin, N. H. June 28, 1912.

60-12. (Figs. 32–67). Migrants developed in elm leaf roll and rosette. Collected June 28–July 12, 1912, from the ventral surface of leaves of *Pyrus americana* (Mountain Ash), to which they had migrated. A fuller account of this collection is given in Journal of Economic Entomology, Vol. 5, p. 397.

61–12. (Figs. 70–73). Elm rosette. Oakland, Me. June 29, 1912.

65–12. Elm rosette. Orono. June 21, 1912.

68–12. (Fig. 1). Elm leaf roll. Houlton, Me. June, 1912.

111–12. (Fig. 5). Elm leaf roll. Orono. July 20, 1912.

113–12. (Figs. 6 and 7). Elm leaf roll. Orono. July 23, 1912. Purposely collected late for comparison with 43–12 (Fig. 2) which developed June 30 in the same rolls. The difference in the actual size of the antennae and in the number of annulations of the big, thrifty early ones from the juicy leaf and the last individuals to develop in the drying roll would seem suggestive of the physiological effect of the habitat on the size of the individual and the character of the antennae.

165–12. *Pyrus sitchensis* Piper, bark. Orono. Sept. 24, 1912.

175–12. Apple bark. Orono, Me. Sept. 28, 1912.

176–12. (Fig.28). *Crataegus* (*monogyna*) *Oxyocantha*. St. Louis, Mo., September 27, 1911. Mr. J. T. Monell.

NOTE. By elm leaf "roll" is indicated a deformation of a single leaf. By "rosette" is indicated a terminal cluster. (Figs. 442 and 462, Bulletin 203, Me. Agr. Expt. Sta.).

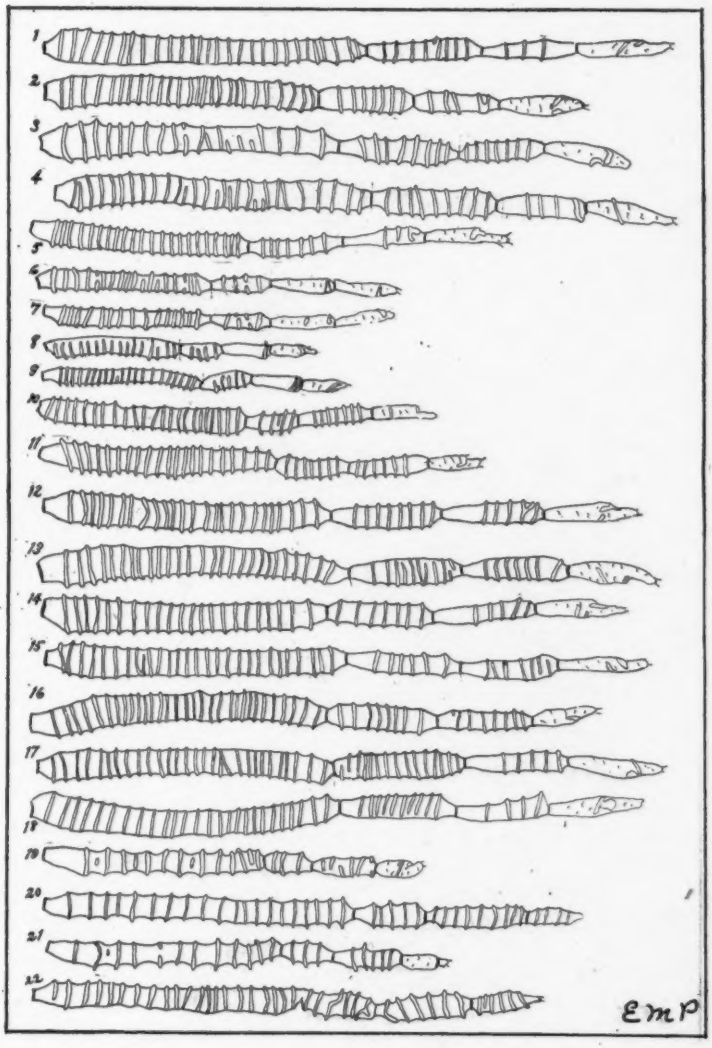
List of Figures With Cross Reference to Collections.

Fig 1, 68–12; Fig 2, 43–12; Figs. 3–4, 53–12; Fig. 5, 111–12; Figs. 6–7, 113–12; Figs. 8–9, 35–12; Fig. 10, 12–12; Fig. 11, 9–12; Fig. 12, 11–12; Fig. 13, 6–12; Figs. 14–18, 50–09; Figs. 19–21, 95–06; Fig. 22, 7–08; Figs. 23–26, 63–11; Fig. 27, 9–12 Sub 1; Fig. 28, 176–12; Fig. 29, 114–06; Figs. 30–31, 115–06; Figs. 32–67, 60–12; Fig. 68, 45–12; Fig. 69, 57–12; Figs. 70–73, 61–12; Fig. 74, 39–04; Fig. 75, 58–12; Figs. 76–82, 49–12; Figs. 83–88, 30–12; Fig. 89, 21–12; Fig. 90, 6–05.

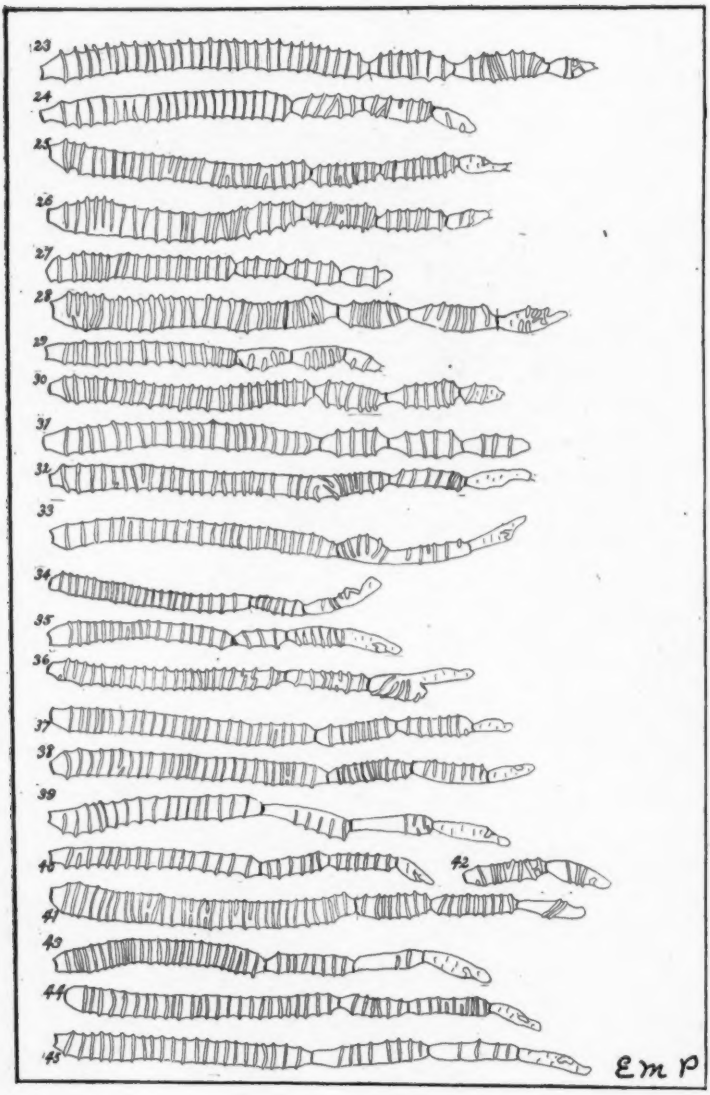
Figs 17 and 18 are right and left antennæ of same individual.

Figs. 37 and 38 are right and left antennæ of same individual.

Figs 64 and 65 are right and left antennæ of same individual.



Edith M. Patch.



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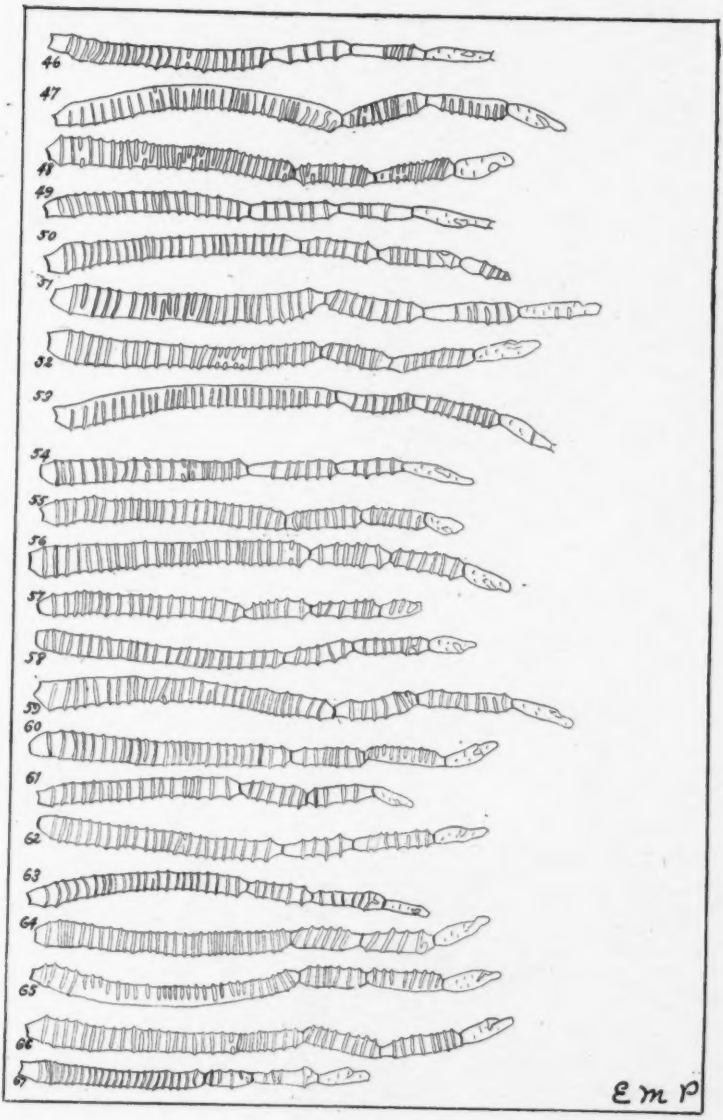

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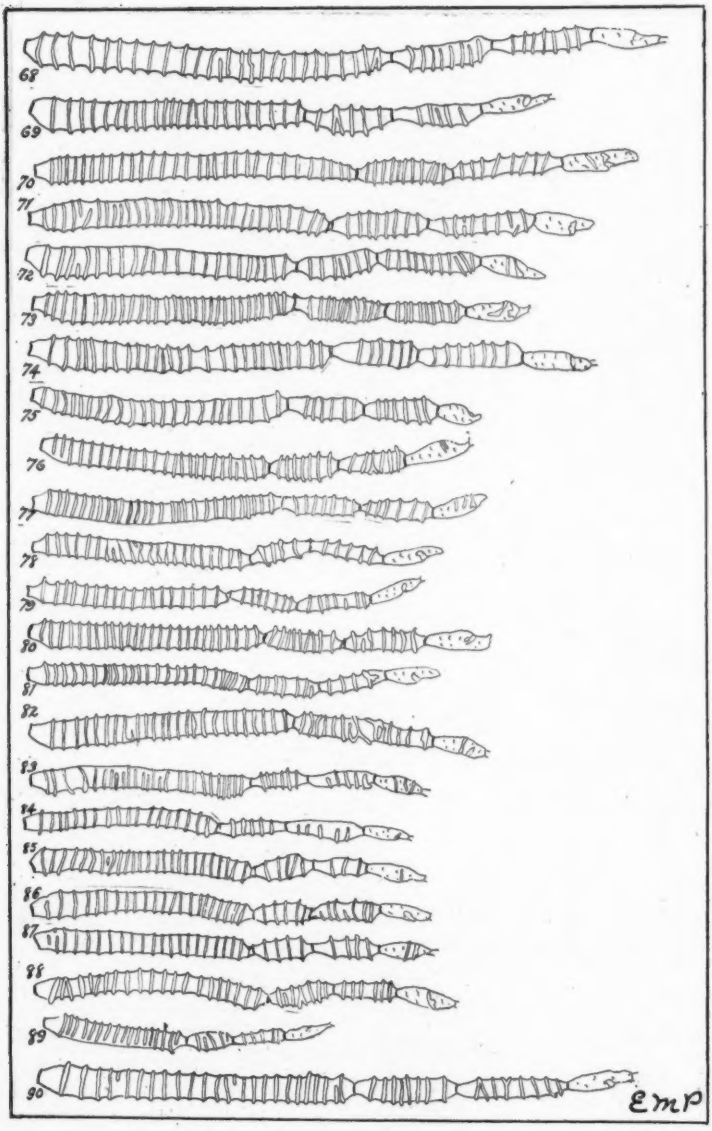

Edith M. Patch.

A STUDY IN VARIATION IN THE NORTH AMERICAN GREENBOTTLE FLIES OF THE GENUS LUCILIA, WITH SYSTEMATIC NOTES ON THE SPECIES INVOLVED.

By JOHN D. TOTHILL,
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Some few years ago the writer had occasion to make a study in variation of the Canadian species of the genus *Lucilia*. Series of adults were bred, more particularly in the case of *L. sericata* Meig., and from the material thus secured the limits and possibilities of variation in certain directions were determined. The fact was brought out that none of the characters made use of by Mr. C. H. T. Townsend in his "Taxonomy of Muscoidean Flies" for the erection of the ten supposedly new species of the genus contained in that publication are of specific value.

In 1911 an opportunity was afforded of examining the types and cotypes of the above ten species at the U. S. National Museum, in Washington, D. C. The conclusion which had been previously arrived at namely, that the supposed species were only variations of the original four species as recognized by Hough was abundantly justified.

Examinations of the ♂ genitalia were made and these again showed that the conclusion was justified.

It is hoped shortly to publish the results of the study of the ♂ genitalia.

The present paper consists of the results of the study in variation, and of the examination of the U. S. N. M. *Lucilia* material.

A STUDY IN VARIATION IN THE GENUS LUCILIA.

That variation in external morphological characters is a factor to be reckoned with in systematic entomology is today disputed by no working entomologist. At the same time there are comparatively an infinitely small number of the vast array of insects described to date which have had their limits of variation approximated.

That such approximation is possible or practical in all cases cannot be entertained; that it is desirable is beyond question. The single historic example of the tachinid fly *Exorista* (*Phryxe*)

vulgaris Fall. with its five and one-half pages of synonymy in the "Katalog der Paläarctischen Diptera" is sufficient in itself to establish the desirability of studies in variation.

The present study is concerned with three species of the genus Lucilia i. e. *sericata* Meig. *sylvarum* Hough and *cæsar* Linn. The method adopted was to breed from isolated egg masses series of adults, examine and record certain selected characters for each fly from each egg mass, tabulate these characters, make synopses of these tables, and finally to draw up from these synopses résumés or extended definitions for each species.

Owing to lack of space only these final résumés appear in this paper. It was the intention of the writer at the outset to keep exact records of at least one hundred examples of each species encountered. This intention was however only realized in the case of *L. sericata* in which case several hundred adults were reared. The number of specimens of each species reared and examined is as follows:

L. sericata, Meig., 158 consisting of 57 ♀♀ and 101 ♂♂.
L. sylvarum, Hough, 27, consisting of 25 ♀♀ and 2 ♂♂.
L. cæsar, Linn., 3, consisting of 1 ♀ and 2 ♂♂.

In addition to these bred specimens ten collected specimens of *L. sylvarum* and thirty-one *L. caesar* were also examined, the results being included in the following *résumés*. This makes the total assemblage of flies for each species: *L. sericata, 158; L. sylvarum, 37; L. caesar, 34.*

The characters selected for examination were as follows:

Dorsocentral bristles.
Postracostichal bristles.
Humeral bristles.
Sternopleural bristles.
Ocellar bristles.
Width of front.
Colour of palpi.
Colour of first abdominal segment.
Marginal bristles of second abdominal segment.
Colour of tegulæ.
Width of apex of first posterior cell compared with the length of the anterior cross-vein.
Presence or absence of appendage at bend of vein four.

These particular characters were chosen for two reasons (a) to find if possible new taxonomic characters for the separation of the species; (b) on account of the fact that they include all the new characters employed by Mr. C. H. T. Townsend* in the erection of ten supposedly distinct species.

* Taxonomy of Muscoidean Flies. Smithsonian Misc. Col., Vol. 41, No. 1803.

RESUME OF L. SERICATA.

In all cases there were three strong pairs of dorsocentral bristles, no rudimentary fourth pair.

In 98.1% of cases there were three pairs of postacrostichal bristles. One of the variations was an extra spasmodically placed bristle of the mesonotum (postsutural). The other variation was that of two postacrostichals only on the left side; this may indicate a past connection between the forms with typically three pairs and those with typically two pairs (L. caesar).

As regards humeral bristles 88.7% of the flies examined were supplied with four strong ones on each side. The variations ranged between a form with two on one side and three on the other and the typic form with four on each side. The anterior bristle was always the one to be lost.

The interior bristle seems to have a taxonomic affinity toward the anterior bristle, as in the case of the latter aborting it was usually found that the interior bristle was weak (in one case it was lost completely on one side).

There were in 96.9% of cases 3 sternopleural bristles on each side. This is a generic character and yet there was variation, not in the species as a whole, but in individuals. These variations were in an increase and decrease of these bristles in both number and strength. In all cases the posterior bristles were constant and the anterior alone became modified.

The ocellar bristles varied according to sex.

82.5% of the female flies had two well-defined pairs. In the great majority of these cases the anterior pair was longer and stronger than the posterior pair, but at the same time the latter pair was sufficiently strong to warrant the application of the term 'bristles'. As to position the anterior pair had their insertion within the ocellar triangle and the posterior pair had theirs outside of the triangle and immediately posterior to it. As to the exceptions to this normal condition of two pairs there were a few cases in which the post. pair were weak; one case in which the two pairs were both exceptionally strong; several instances in which there was an extra *bristle* developed on one side within the ocellar triangle and posterior to the normal anterior pair; and finally a few instances in which there was an extra *pair* of bristles developed within the ocellar triangle and post. to the ant. pair.

Of the males 90% had only one pair of ocellar bristles. These were proclinate and had their insertion within the triangle. There was a tendency toward the production of two pairs; in some cases this second pair was hardly stronger than the surrounding hairs; in 7% of cases they had developed into a weak posterior pair; and finally in a solitary instance two distinct pairs were developed.

The width of front affords a secondary sexual character. This character was very constant, there being practically no variation in all the material examined.

In the females the width was one-seventh to one-eighth head width. Hough in his description of this species gives one-sixth to one-eighth head width; this will hold good if that portion near the ocellar triangle is taken into consideration, as at this extremity there is an expansion. In the present study, however, the term width of front is restricted to that portion of the front immediately above the base of the antennae, i. e. the narrowest portion.

In the case of females the width of front was from one-tenth to four-tenths head width.

It may be stated here that measurements of all these flies was not attempted. A small series however of each sex were measured in this particular and with these as a guide the other specimens were visually compared. This may sound somewhat casual, but in reality the method is reasonably accurate as the observer very quickly acquires a due sense of proportion.

The next character lies in the color of the palpi. This character was sometimes very difficult to determine because the palpi were often retracted into the oral cavity. The wall of this cavity varied from an amber yellow color to almost black and the palpi, being semi-transparent, appeared in many cases to be of this dark color and only by removing them could the fallacy be made patent. Again these palpi were covered with fine white hairs and thus in certain planes of vision they appeared white.

The prevailing color of these palpi was amber yellow. This was however by no means constant, there being but 64.4% of the flies with the palpi of this color. The color varied from pale yellow through dark amber yellow to almost black; again in several cases there was an infuscation or dark area at the distal region; and also a black area was occasionally present

at the base. Thus for this species at least the color of the palpi is not constant and the infuscation at the tip has no specific value.

In the color of the first segment of the abdomen was found an excellent secondary sexual character. In all cases it is the dorsal area of the segment that is referred to and not the ventral.

In all males examined the first segment was, at least superiorly, black. In the females this segment varied from the color of the remaining segments (i. e. abdomen unicolorus) to a shade darker; there were few examples of this latter condition.

On the second abdominal segment there was superiorly a row in both males and females, of fairly strong marginal macrochaetae. These marochaetae were stronger centrally, then became weak and finally became strong again at the sides. These bristles varied slightly, but not to any marked degree; in a few cases they were strong and in a few cases weak; in two instances (1 ♂ and 1 ♀) the two median bristles stood out more prominently thus approaching the condition in *L. sylvarum*.

The tegulae varied from white to brown. This variation was evident in all the series of flies of all species and in one lot of *L. sylvarum* bred from a single egg cluster all intermediate stages were found between the pure white and the brown conditions.

Before passing to the next character it may be well to observe that all flies killed and pinned soon after the time of issuance have pure, or almost pure, white tegulæ; and that only in flies that have either been collected, or bred through and left in a cage for ten days or more, have the brown-tinged tegulae been observed. This seems to indicate that the tegulae darken as the fly grows older.

It was found that the width of the apex of the posterior cell in comparison with the length of the anterior cross-vein was slightly or distinctly shorter; the only exception to this was in the case of two flies in which the lengths were equal. This character has not previously been made use of. It is apparently very constant and serves as a separating character for this species from *L. sylvarum*.

The character is best seen when the wing is viewed from below. In vein 4 there was in no case any appendage—even rudimentary—at the angle.

RESUME OF L. SYLVARUM.

There were in all cases 3 strong pairs of dorsocentral bristles, but in 33% of the flies resulting from one egg cluster there was a trace of a fourth anterior pair; sometimes this trace exhibited itself as a slightly exaggerated hair on one side only and sometimes it resolved itself into a distinct but weak pair of anterior dorsocentral bristles. There were three pairs of strong postacrostichal bristles in all cases.

As regards humeral bristles there were in most cases four on each side. The majority of variations ran to an abortion of either one bristle on one side only, or of a bristle on both sides. This bristle was always the anterior bristle and, as in *L. sericata*, the loss of it carried with it a weakening of the anterior one. There was in one case a variation in the other direction, namely, the development of an extra bristle, quite strong, on one side only.

Sternopleural bristles were represented by three typical pairs, but, as in *L. sericata*, there was variation, notwithstanding the fact that the character has an undoubted generic value. This variation appeared in 4 specimens and ran in each case to an additional anterior pair, represented either by a bristle on one side only or by a bristle on each side; these bristles were sometimes weak and sometimes strong. In all cases as in *L. sericata*, only the anterior bristles were subject to modification.

Coming to ocellar bristles it was found that, as in *L. sericata*, these afforded secondary sexual characters. The four males had only one strong pair of ocellar bristles. These were proclinate and inserted within the ocellar triangle.

The females had one strong pair inserted within the ocellar triangle and one very weak pair inserted outside the triangle and immediately posterior to it. This weak pair was made up of somewhat exaggerated hairs but the term bristle is perhaps applicable because they stood out from the surrounding hairs (of which there were several pairs). There were in the specimens of this species as in the specimens of *L. caesar* a few hairs within the ocellar triangle. There was variation from the typical condition of one strong pair and one weak in two directions, namely, reduction of the posterior pair and the addition of another posterior pair of these weak bristles or strong hairs.

The width of front affords a secondary sexual character. In the males the front was from one-tenth to one-twelfth head width. Hough gives the width as "very narrow" and "one-eighth to one-tenth head width." A better way is perhaps to say that the width of front in ♂ *L. sylvarum* comes intermediate between that of *L. caesar*, which is linear, and that of *L. sericata* which is from one-seventh to one-eighth head width. Once having examined specimens as to this character in males of all three species it becomes a comparatively easy task to subsequently reduce any male *Lucilia*, on this character alone to its species.

The front of the females was found to be somewhat narrower than in *L. sericata* and about the same as in *L. caesar*. In actual width it was found to be about 3-10 (measurements were made in a number of specimens) of the head width; this is slightly less than 1-3 head width. This character serves very nicely for separating females of this species and of *L. caesar* from females of *L. sericata* which have a front measuring 4-10 head width, or slightly greater than 1-3 head width.

The color of the palpi appears to be far more constant in this species than in *L. sericata*. This color was dark brown or almost black in all but two cases and in these it was black. The color of the dorsum of the first abdominal segment was *not* in this case found to afford a secondary sexual character as in *L. sericata*. In the females the first abdominal segment was either blackish or black, and in the males it was black.

A comparative study of the bristles of the second abdominal segment produced some curious results. In the case of *L. sylvarum* one bred male had a strong pair of median marginal bristles and no differentiated marginal row. 68% of the females in the same lot had a strong central pair of bristles and a weak marginal row; several flies had the central pair no stronger than the remaining bristles of the marginal row. Again in another lot of bred material of 7 females two exhibited this latter condition of having the central pair no stronger than the others.

This variation is important because the presence of a pair of strong median marginal macrochaetae has always been attributed by writers to *L. sylvarum* and here it is shown that the character may vary to quite a considerable extent.

In most cases the central pair were of about the same strength as the remaining bristles. As a rule, however, these

two bristles stood out at right angles, or at least at a considerable angle, to the longitudinal plane of the abdomen; whereas the remaining bristles were barely elevated and extended over the dorsum of the third segment. Thus these central bristles stood out as two distinct macrochaetae. It not infrequently happened however that these central bristles were not elevated and hence they could not be readily distinguished from the others of the marginal row and inference was naturally drawn that they were not present. Their presence could usually be detected by examining the sites of their insertions as compared with those of the remaining bristles; the central pair had their insertions very slightly anterior to the row of marginal macrochaetae.

The tegulae varied, as in *L. sericata*, from white to smoky; in one lot of bred material particularly an excellent gradational series, in respect to this character, was obtained.

The apex of the first posterior cell of the wings was, unlike the condition in *L. sericata* or *L. caesar*, longer than the anterior cross vein. This character is best seen from the under surface of the wing. It is apparently one of the best for separating this species from *L. sericata*. There was often a short spur at the angle of the fourth longitudinal vein.

RESUME OF L. CAESAR.

In all cases there were three strong pairs of dorsocentral bristles and there was no rudimentary or vestigial fourth pair.

In all cases but one, two pairs of postacrostichal bristles were found to be present. In this one exception there was an extra pair erratically placed.

The humeral bristles varied considerably. In the bred specimens there were two flies with two pairs and one fly with three pairs. The most common condition was two pairs, but there were a number of specimens with an extra anterior bristle on each side, and again others with a complete anterior fourth pair. At the other extreme there was a fly with two bristles on one side and three on the other. There was thus greater inconstancy of humeral bristles in this species than in either of the other two. It is interesting to note that it was always, as in *L. sericata* and *L. sylvarum*, the anterior bristles and of these the interior pair that were subject to variation.

The sternopleural bristles were represented in all cases but one by the normal three pairs. In this one exception the anterior bristle on one side was reduced to a long hair. It was the anterior bristle that became modified.

The ocellar bristles, as in the other two species, afforded secondary sexual characters.

The males had in all cases the one strong proclinate pair as in *L. sericata* and *L. sylvarum*, having insertion within the ocellar triangle. The females had the usual one strong pair having insertion within the ocellar triangle. The posterior pair were in most cases reduced to hairs, thus being less strong even than in *L. sylvarum*. There was one curious variation in which there were one strong pair and two very weak pairs of bristles; both these weak pairs were posterior to the strong anterior pair; one of them was inserted within and the other outside of the ocellar triangle. There were in addition to the bristles a number of hairs both within and outside of the triangle.

The color of the palpi was, in the specimens of this species examined, very constant. It was without exception amber yellow.

The width of front here again afforded a secondary sexual character. All the males had the front linear; it was considerably narrower than in *L. sylvarum*, and very considerably narrower than in *L. sericata*. In the females the width of front varied from three tenths to one third head width; the more general condition however was about three tenths, or the same as in *L. sylvarum*.

The color of the dorsum of the first abdominal segment varied from that of the remaining segments (abdomen unicolorous) to black. Between these two extremes there were numerous gradational variations; the most common of these was that in which the segment was somewhat darker, especially centrally, than the remaining segments.

As to the color of the tegulae there were found to exist the same variations as in *L. sylvarum* and *L. caesar*. The extremes were white and brown and between these were found numerous combinations. The more common condition was that of 'tinged brown.'

Regarding the last character, namely, the comparison in lengths of the apex of the first posterior cell and anterior cross

vein it was found that this species comes in this respect midway between *sericata* and *sylvarum*. In four cases the apical margin of the first posterior cell was slightly shorter than the length of the anterior cross vein, which is the typical condition in the case of *L. sericata*. In the remaining twenty seven flies it was about equal to the length of the anterior cross vein. Thus for this species the character will not serve to differentiate from the other two species.

Having completed the résumés for the three species of *Lucilia* the opportunity may be taken to make a few general remarks on characters which have not been made use of in the tables.

First, as to size, there was found to be little difference in the three species. Possibly *caesar* is generally somewhat larger than the other two. In each species there is however a considerable variation. To illustrate this it may be said that in over 200 specimens of *sericata* the smallest fly was 5 mm. long and the largest 9 mm.; the average length was from 7 to 8 mm.

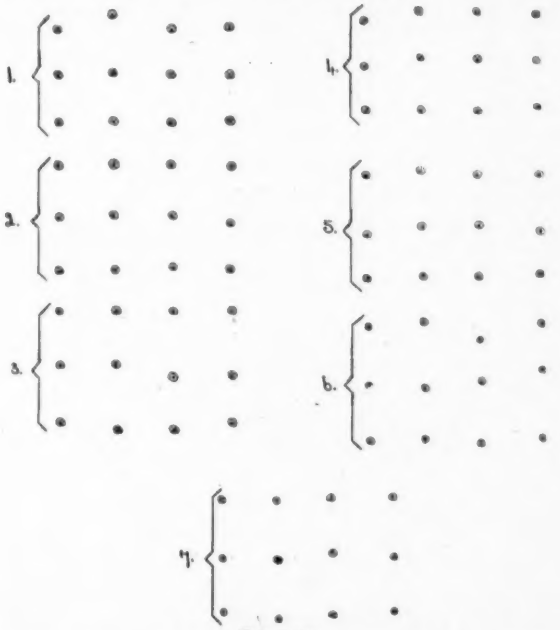
Then as to general color there was again a great range of variation. Hough makes remark* that 'In all the Calliphorineae of metallic color the shade varies through violet, green, blue and copper color.' One has only to look at a long series of Lucilia to find that, in this genus at least, the remark holds true. Generally, however, flies of *L. sericata* are brighter, owing to a greater preponderance of the coppery color, then are those of *L. caesar* and *L. sylvarum*..

Lastly a word may be said regarding the positions of the dorsocentral and postacrostichal bristles both in relation to the respective series separately and in relation to one another As to the positions in their respective series it was found that they were placed, almost without exception, in the same plane longitudinally (cephalad-caudad) although there was variation. Then as to the relative positions of the dorsocentrals and postacrostichals there was found to exist a considerable variation: taking any four bristles transversely an imaginary line drawn through their insertions usually approached a straight line; this line was however scarcely ever absolutely straight and the deviations from it did not follow any definite plan. The

*Synopsis of the Calliphorineæ of the U. S., Zool. Bull., Vol. II, No. 6, Sept., 1899, p. 283.

accompanying diagram showing the positions of these thoracic bristles in the case of seven flies all bred from a single parent indicate this variation better than can any description.

The point is of interest on account of the fact that Mr. Townsend (loc. cit. p. 121) in describing a new species of Lucilia (*L. giraulti*) makes use of the relative positions of the postacrostichal and dorsocentral bristles.



DIAGRAM

Showing variation in relative position of dorsocentral and postacrostichal bristles in the case of 7 specimens of *L. sericata*, all bred from the same parent fly.

Legend:

Each dot within a circle represents the insertion of a bristle.
Each bracketed group (of the total 7) represents the dorsocentral and postacrostichal bristles of one fly.
The two outside rows of bristles are dorsocentrals.
The two inside rows of bristles are postacrostichals.

The chief value of this study in variation lies in the fact that each species dealt with was found to be subject to considerable variation in the matter of chaetotaxy, color, size, etc. Also in that all the new characters used by Mr. Townsend (loc.

cit.) for the erection of the ten supposedly distinct species are shown to come within the limits of variation of the North American species of *Lucilia* as recognized by Hough.

NOTES ON THE TYPES AND CO-TYPES OF LUCILIA SPECIES IN THE U. S. NATIONAL MUSEUM.

The following notes were made in 1911, through the courtesy of the U. S. N. Museum authorities, on the types and cotypes of Mr. Townsend's supposedly new species of Lucilia. In some cases the Taxonomy of Muscoidean Flies, Smithsonian Misc. Col., Vol. 41, No. 1803, notes refer to the original descriptions. The value of certain characters employed in these descriptions is discussed in the preceding portion of this paper.

Lucilia morilli. Town.

The type specimen together with all the co-types are *Pseudopyrellia cornicina* Fab. There are no hypopleural bristles and the fourth vein is curved and not angular.

Lucilia nigripalpis. Town.

The type specimen must be referred to *L. sylvarum* Meig. The width of front is slightly less than one-third head width; the palpi are blackish; the first segment of the abdomen is blackish; on the second segment of the abdomen there is a well marked pair of median marginal macrochaetae quite as strong as are found in most specimens of *L. sylvarum*. The abdomen is however 'dented' in consequence of which the macrochaetae are appressed against it and this is presumably the reason that they were overlooked by the author of the species; there is a weak pair of extra ocellar bristles just posterior to the ocellar triangle and quite typical of *sylvarum;* in the comparative lengths of the apex of the first posterior cell and the anterior cross vein the fly is typically *sylvarum*.

The co-type is an undeveloped specimen of *L. sylvarum* Meig; the head characters are all typical except in the color of the palpi which are distinctly brownish, especially toward the base; the lower side however of the abdomen and also the legs both show this light color which means that the fly was captured soon after issuing; toward the tip the palpi become blackish and this is carried down one fourth distance to base; as to marginal macrochaetae on the abdomen there is a weak pair on the second segment which show up better when the fly is examined from the dorsal side; when the specimen is viewed laterally there is seen to be one other bristle near the center of the same segment; it is about as long as the shorter of the central pair but the base is weaker.

Lucilia angustifrons. Town.

The type specimen is a ♂ from England and the single co-type is a ♀ from Kaslo, B. C., which "seems to be this form"(Townsend, Taxonomy of Muscoidean Flies, p. 120). An examination of the type shows that a third and anterior pair of postacrostichal bristles is present; at the same time both these bristles are weaker than those situated posterior to them in the same rows and moreover the bristle on one side is decidedly less strong than that on the other side (the one on left side is weaker). This is the only character that separates the fly from typical *L. caesar* and as in this very character there is an irregularity it seems highly probable that the pair of bristles is nothing but a sport in which çase the form must be referred to *L. caesar* Linn.

As to the single co-type, the ♀ from Kaslo, this fly has two postacrostichal bristles on one side and three on the other with the anterior one weak; the fly is unquestionably *L. caesar* Linn.

Lucilia giraulti. Town.

One ♂ from Paris, Texas, no cotypes. In the original description of this species (Townsend, Taxonomy of Muscoidean Flies, p. 121) there is only one character mentioned that would separate the form from *L. sericata* Meig. which is that "a second pair of ocellar bristles is present." Even were this so the character would be insufficient in itself as the study of variation for *L. sericata*, brought out the fact that in this species there is occasionally developed a second pair of ocellar bristles. An examination of the specimen itself however shows that the bristles in question are *not* developed. The fly is therefore *L. sericata* Meig.

Another character used in the description of this species is the position of the postacrostichal bristles relative to the dorsocentrals. The study in variation brought out the fact that this character has no determinative value. The above specimen is badly mutilated.

Lucilia barberi. Town.

A discussion of this supposed species is hardly necessary. All the characters employed to separate the form are met with

in *L. sericata* Meig. An examination of the type specimen and also of four cotypes shows that the form may be referred to *L. sericata* Meig.

Lucilia unicolor.

Five ♀ specimens from New Mexico, Mexico and British Columbia. They are all *L. caesar* Linn. The second pair of ocellar bristles is fairly strong in the type specimen, but in the co-types there is variation and they become less strong, in any case all come within the limits of variation of *L. caesar*.

Lucilia purpurea. Town.

There is no character in the description of this form which serves to separate it from *L. caesar* Linn. In the description it is stated that "the whole body is purplish, strongly violet tinged, especially in the ♀." This is certainly somewhat of an unusual hue for *caesar*, but a series can be arranged from the U. S. N. Museum material showing all gradations from this form to almost pure green. An examination of the type and co-type shows that there are no structural characters separating the form from *L. caesar* and the name *purpurea* Town. must therefore sink.

Lucilia australis. Town.

Two ♀ ♀ from the southern states and one ♂ from Alaska. The type and one co-type, both from the southern states, must be referred to *L. pilatei*. Hough. The ♂ from Alaska agrees with *L. caesar* Linn. in everything except the width of front which appears to be very slightly greater than in *L. caesar*. This, however, is probably partly optical, as the inner margins of the eyes, in the region of the ocellar triangle, are blackish, and thus appear to be part of the front.

Lucilia infuscata. Town.

From the description (Townsend. Taxonomy of Muscoidean Flies, p. 123) it is evident that the ♂ ♂ are *L. caesar* Linn. as all the characters enumerated come within the limits of variation of that species.

The ♀ ♀ of which there are six, "can be told from *caesar* only by the narrower front and darker basal segment." As to the latter of these characters the study in variation for *L. caesar* brought out the fact that in that species the first segment

of the abdomen is not unicolorous with the other segments, but darker. As to the former character, i. e., the 'narrower front,' the more general condition met with in *caesar* as to width of front is less than one third head width, or to be more specific three tenths head width; *infuscata* is described as having the front two-sevenths head width and the difference between three-tenths and two-sevenths is one-seventieth, which reduces the character as a differentiating one to an absurdity.

An examination of the type and co-type bears out the above remarks and proves the form to be *L. caesar* Linn. with the exception of one co-type which is *Phormia regina* Meig.

Lucilia oculata. Town.

Six ♂♂ and two ♀♀. The former are *L. caesar* Linn. and the latter are *L. pilatei* Hough. The author of *oculata* lays stress on the color of the face and antennae, which are described in this instance as brownish yellow instead of black. After examining the U. S. N. Museum *caesar* material the writer found that taking three specimens from England, one from Mexico and one from Connecticut an excellent gradational series could be made, showing transition from black to light reddish brown. In this connection it may be stated that the late Mr. D. W. Coquillett collected a specimen of *L. pilatei* Hough, in Washington, D. C., which exhibits some remarkable colorational features. The whole fly is quite light, especially the legs and venter, but it is distinctly 'shot' with green and blue, so that in different lights it takes on different colors; the parafacials are pale reddish yellow. It is the experience of the writer that, within certain limits, the earlier a specimen of Lucilia is captured after issuance the lighter will be the color.

The synonymy indicated in the above notes on the types and co-types of Lucilia species in the U. S. N. Museum may be listed as follows;

Lucilia morilli, Town = Pseudopyrillia cornicina, Fab.
Lucilia nigripalpis Town = Lucilia sylvarum, Meig.
Lucilia angustifrons Town = Lucilia cæsar, Linn. (abnormal fly).
Lucilia girault Town = Lucilia sericata Meig.
Lucilia barberi Town = Lucilia sericata Meig.
Lucilia unicolor Town—Lucilia cæsar Linn.
Lucilia purpurea Town = Lucilia cæsar Linn.
Lucilia australis Town = Lucilia cæsar Linn.
Lucilia infuscata Town = Lucilia cæsar Linn.
Lucilia infuscata Town = (1 cotype) = Phormia regina Meig.
Lucilia oculata Town, male = Lucilia cæsar Linn.
Lucilia oculata Town, female = Lucilia pilatei, Hough.

It may be stated that Mr. W. R. Thompson and the late Mr. D. W. Coquillett examined independently the above material and both gentlemen substantially confirmed the above synonymy. Before leaving the subject of synonymy the opportunity may be taken of making a few remarks on some species listed in Aldrich's catalogue of North American Diptera. As regards Lucilia sylphida, Bigot. a copy of the original description (Ann. Soc. Ent. de France 1877, p. 45,) which was furnished the writer through the courtesy of Prof. J. M. Aldrich, is as follows:

"17. S. Sylphida female (nov. sp?).

Viridi metallico. (Abdomen?) Antenn. segmento 3.0 secundo quadruplo longiore. Alis, vena 4a usque ad apicem primæ spinosa. Cicatrice subhumerali nigra. Facie, basi tantum, duobus macrochaetis munita. Antennis palpisque pallide testaceis. Fronte grisea, occipite utrinque, obscure ænescente, vitta nigra apice fulva, facie albida, genis pallidissime testaceis; calyptris albis; alis hyalinis basi, pallidissime testaceus; pedibus, fusco-nigra, femoribus, extrinsecus, parum æneis. (L'abdomen manquant, est cl bien une espece nouvelle?)"

In this brief description mention is made of none but generic characters and these in a most general way. The form is probably not a distinct species, but this can only be ascertained by an examination of the type. As to some of the other species:

Lucilia mollis, Walk.

Hough refers doubtfully to Phormia regina.

Lucilia rufipalpis, Jaen.

Hough refers to Phormia regina.

Lucilia nobilis, Meig.

Mr. Austen, of the British Museum writes that this form is now generally considered to be synonymous with *L. sericata*.

Lucilia sylphida, Big.

Probably not a distinct form.

Lucilia terræ-novæ, Des.

Hough refers to Phormia.

OBSERVATIONS ON THE CHÆTOTAXY OF CALLIPHORINAE.*

By Phineas W. Whiting.

LUCILIA.

In his "Synopsis of the Calliphorinæ (Diptera) of the United States" (Zool. Bull. 1899, Vol. 11, No. 6), Garry de Neuville Hough defines our species of Lucilia as follows:

"Two postacrosticals. Front of male linear, of female one-third as wide as the head; abdomen unicolorous. *cæsar* L.

"Front of male not linear, at narrowest part about one-eighth as wide as the head; front of female about one-fourth as wide as the head; abdomen not unicolorous, first segment and hind margins of second and third blackish, contrasting strongly with the remainder *pilatei* nov. sp. [Hough]

"Three postacrostalis. Palpi black; front of male very narrow, that of female about one-third as wide as the head; abdomen with two stout marginal macrochætæ on the second abdominal segment. *sylvarum* Meig.

"Palpi yellow; front of male varies from one-eighth to one-sixth as wide as the head, that of female about one-third as wide as the head; second abdominal segment without marginal macrochætæ. *sericata* Meig."

Moreover, he says, "The chætotaxy is invariable for each species except for an occasional evident deformity, and it differs in the different species only in the number of achrostical bristles."

Observations were made on this subfamily during the past season and especial attention was given to the matter of chætotaxy in Lucilia. Thus some estimate may be obtained of the extent of deformity as it occurs in nature. Female flies of this genus, moreover, were obtained alive and set in cages containing fish, in order that their offspring might be obtained for the purpose of studying the range of variation in the progeny of the separate females. Each family probably represents the offspring of several males as copulation is frequent. The bristles studied comprise only the achrosticals and the dorsocentrals posterior to the transverse suture of the thorax, with the exception that in *L. sylvarum* the marginal bristles on the second abdominal segment were recorded as they showed considerable divergence from the normal condition recorded by Hough and are regarded as a specific character.

*Contributions from the Entomological Laboratory of the Bussey Institution, Harvard University, No. 67.

The post-sutural dorso-centrals and achrosticals in *L. sericata* form a group of twelve in four rows of three each as shown in the diagram (Fig. 1). This arrangement is recorded as 3, 3, 3, 3, the separation into rows being denoted by commas.

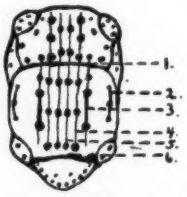


Fig. 1. Thorax of *Calliphora viridescens* to show typical arrangement of post sutural bristles. 1. Transverse suture. 2. Supra-alar bristles. 3. Intra-alar bristles. 4. Dorso-central bristles. 5. Post acrostical bristles. 6. Scutellar suture.

When one or two of the anterior bristles of a row are omitted, the row is denoted by 2 or 1 respectively.

In order to denote the omission of the second or third bristle when those anterior to it are not omitted, the normal positions of the bristles are recorded as a, b, and c, from anterior to posterior. Thus a row lacking the second bristle would be called ac.

Addition of a supernumerary bristle into a row is denoted by ! inserted in the proper position between or in front of the letters denoting the normal bristles. Thus addition of a bristle in front of a row would be expressed by calling the row !abc. But in some cases the number of bristles alone was recorded for each row and the row was called 4 or 5, according to whether one or two bristles were added.

Insertion of a supernumerary bristle between the normal rows is denoted by parentheses enclosing a, b, or c, according to the position of the bristle from anterior to posterior. Thus a definition as 3, (a), 3, 3, 3, would denote the addition of a bristle between the first left post-dorso-central and the first left post-achrostical.

Additional bristles are usually smaller than the normal, but range all the way from microchaetæ to the size of the normal macrochaetæ. A small bristle is denoted by italics.

The records of wild flies are first noted, and these are followed by an account of the breeding experiments.

On July 29 the following were taken at meat near the Bussey Institution, Forest Hills, Mass.

L. sericata: 277 individuals—3, 3, 3, 3. 1 ♂ —3, 3, ab, 3.
1 ♀ —5, 3, 3, 4. 1 ♀ —3, 2, 2, 4.
4 ♀♀—3, 2, 2, 3. 2 ♀♀—3, 3, 2,3 .
2 ♀♀—3, 3, 3, 4. 1 ♀ —3, 4, 3, 3.
1 ♀ —3, 3, 4, 3. 1 ♂ —3, 2, 3, 3.

The frequent lack of anterior post-achrosticals either on one or on both sides is interesting as it denotes approach toward L. caesar. The general habitus, however, is typical sericata. A single specimen of caesar taken in this lot was 3, *a*bc, *a*bc, 3. Thus it appears that chaetotaxy alone cannot be relied upon to determine the species with certainty. This will appear from the following observations and even more clearly from the breeding experiments.

On Aug. 5, at meat at Bussey Institution, were taken:

L. sericata: 311 indidivuals—3, 3, 3, 3. 1 ♂—3, ac, 3, 3.
1 ♂—3, 3, 2, 3. 1 ♀—3, 3, 2, 3.
1 ♀—3, 3, ac, 3.
L. cæsar: 1 ♀—3, 2, 2, 3.
L. sylvarum: 1 ♀—3, 3, 3, 3, with two bristles on margin of second abdominal segment (for brevity written 2 ab. br.)

On Aug. 6, at meat at Bussey Institution, were taken:

L. sericata: 68—3, 3, 3, 3. 1 ♂—3, 2, 3, 3.

On Aug. 8, at the garbage scow, Boston, were taken at meat:

L. sericata: 955 individuals—3, 3, 3, 3. 1 ♂ —3, ac, 3, 3.
1 ♂ —3, ac, 3, 3. 1 ♂ —3, 3, 2, 3.
2 ♂♂—3, ab ! c, 3, 3. 1 ♀ —3, *a*bc, 3. 3.
1 ♀ —3, 1, 2, 3. 1 ♀ —3, ac, ac, 3.
1 ♀ —4, 3, 3, 4. 1 ♀ —3, 3, 4, 4.
1 ♀ —3, 4, 3, 3. 1 ♀ —3, 2, 1, 3.
5 ♀♀—3, ac, 3, 3. 2 ♀♀—3, a*b*c, 3, 3.
3 ♀♀—3, 3, ac, 3. 3 ♀♀—3, 3, 2, 3.
4 ♀♀—3, 2, 3, 3.

Flies having the habitus of cæsar were as follows:

5 ♂♂—3, 2, 2, 3. 9 ♀♀—3, 2, 2, 3.
1 ♀ —3, *a*bc, 2, 3.

On Aug. 9 at a short distance from Bussey Institution on leaves near a pond the following were taken:

L. sericata: 1 ♂ —3, 3, 3, 3.
L. cæsar: 1 ♀ —3, 2, 2, 3.
L. sylvarum: 2 ♂♂—3, 3, 3, 3, with 2 ab. br.
1 ♂ —3, 3, 2, 3, with 2 ab. br.
4 ♀♀—3, 3, 3, 3, ab. br. lacking.

On Aug. 10 at same place the following were taken at meat:

L. sericata: 4 ♂♂—3, 3, 3, 3. 100 ♀♀—3, 3, 3, 3.
2 ♀♀—3, 2, 2, 3. 2 ♀♀—3, a / bc, 3, 3.
1 ♀ —3, (*a*), 3, 3, 3.
L. cæsar: 3 ♂♂—3, 2, 2, 3. 20 ♀♀—3, 2, 2, 3.
L. sylvarum: 1 ♂ —3, 3, 3, 3, with 2 ab. br.
1 ♀ —3, 3, 3, 3, with 2 ab. br.
An indeterminate ♂ Lucilia—3, *a*bc, *a*bc, 3.

On Aug. 12, at same place on leaves were taken:

L. sericata: 1 ♀ —3, 3, 3, 3.
L. sylvarum: 14 ♂♂—3, 3, 3, 3, with 2 ab. br.
2 ♂♂—3, 3, 3, 3, with 3 ab. br.
1 ♂ —3, 3, 3, 3, with 4 ab. br.
1 ♂ —3, 3, a / bc, 3, with 2 ab. br.
1 ♀ —3, 3, a / bc, 3, with 2 weak ab. br.

On Aug. 14, at same place, on leaves were taken:

L. sericata: 1 ♀ —3, 3, 3, 3.
L. cæsar: 4 ♀♀—3, 2, 2, 3.
L. sylvarum: 5 ♂♂—3, 3, 3, 3, with 2 ab. br.
1 ♂ —3, 3, 2, 3, with 3 ab. br.
2 ♂♂—3, 3, 3, 3, with 4 ab. br.
1 ♂ —3, a / bc, ab / c, 3, with 2 ab. br.
3 ♀♀—3, 3, 3, 3, ab. br. lacking.

And at meat:

L. cæsar: 2 ♂♂—3, 2, 2, 3.
21 ♀♀—3, 2, 2, 3.
L. sericata: 6 ♂♂—3, 3, 3, 3.
225 ♀♀—3, 3, 3, 3.
1 ♀ —3, 3, 3, / abc.
2 ♀♀—3, a / bc, 3, 3.
1 ♀ —3, 3, a / bc, 3.
1 ♀ —3, ac, 3, 3.
L. sylvarum: 1 ♀ —3, 3, / abc, 3, with 2 weak ab. br.

On Aug. 15, in meadow near Bussey Institution were taken at meat:

L. cæsar: 1 ♂ —3, 2, 2, 3.
L. sericata: 8 ♂♂—3, 3, 3, 3.
145 ♀♀—3, 3, 3, 3.
1 ♀ —3, 3, 3, / abc.
1 ♀ —3, a / bc, 3, 3.
1 ♀ —a / bc, 3, 3, 3.
1 ♀ —3, 3, a / bc, 3.

On Aug. 29, at Hartland, Vt., by the bank of the Connecticut River at some distance from any house were taken at meat:

L. cæsar: 1 ♂ —3, 2, 2, 3. 32 ♀♀—3, 2, 2, 3.
1 ♀ —3, 3, 2, 3.
L. sylvarum: 3 ♀♀—3, 3, 3, 3, with 2 well developed ab. br.

On Oct. 17, at garbage scow, Boston, were taken at meat:

L. sericata: 28 ♂♂—3, 3, 3, 3. 351 ♀♀—3, 3, 3, 3.
1 ♂ —3, 2, 2, 3. 1 ♂ —3, 3, 2, 3.
1 ♀ —3, 2, 2, 3. 1 ♀ —3, 3, 2, 3.
1 ♀ —3, 2, abc, 3. 1 ♀ —3, 3, ac, 3.
1 ♀ —3, ac, ac, 3. 1 ♀ —3, 3, 3, ab / c.
1 ♀ —/ abc, 3, 3, / abc.

In all cases habitus rather than chætotaxy has been taken as the criterion of specific determination, and this I believe to be more reliable on account of my breeding experiments. By habitus I mean general coloration and slight differences of form which would be very hard to define verbally. The width of the front is also important here. The habits are also somewhat different, as may be seen from the observations. L. *sylvarum* appears to be the wildest form, being without excep-

tion taken at some distance from buildings. *Sericata* is more commonly present either inside or very near buildings, while *caesar* may be taken in either situation, but more frequently along with *sylvarum*. It would be of considerable interest to study the distribution of these species over a more extensive area.

In order to get an approximate estimation of the percentage of individuals abnormal in chaetotaxy, I have added the sericatas and find them as follows:

Normal—2,479 individuals. Abnormal by reduction—47 individuals or 2 %. Abnormal by addition—23 individuals or 1%. Abnormal by reduction and addition— 1 ♀—3,2, 2, 4, or .04%.

The variants by reduction are here 10 ♂♂ and 37 ♀♀, while the variants by addition are 2 ♂♂ and 22 ♀♀. The excess of females is of course due to the fact that the flies were taken at meat.

Some of the flies were bred to show the character of the progeny, and these showed results as follows:

L. sylvarum: ♀ —3, 3, a / bc, 3, with 2 very small ab. br., taken by pond near Bussey, Aug. 12, gave all females in progeny as follows:
9 ♀♀—3, 3, 3, ab. br. lacking.
2 ♀♀—3, 3, 3, 3, with 2 small ab. br.
1 ♀ —3, / abc, 3, 3, ab. br. lacking.
3 ♀♀—3, 3, a / bc, 3, ab. br. lacking.
1 ♀ —3, / abc, / abc, 3, ab. br. lacking.
This suggests that an extra post-sutural bristle may be inherited.

L. cæsar:
♀—3, 2, 2, 3, from Bussey Pond, Aug. 14, gave 18 ♂♂—3, 2, 2, 3.
13 ♀♀—3, 2, 2, 3. 1 ♂—3, b, 2, 3.
♀—3, 2, 2, 3, from Bussey Pond, Aug. 10, gave 13 ♀♀—3, 2, 2, 3. No males.

L. sericata:
♀—3,3, 3, 3, from Bussey Institution, July, gave
51 ♂♂—3, 3, 3, 3.
35 ♀♀—3, 3, 3, 3. 1 ♀—3, 3, a / bc, 3.
♀—3, 3, 3, 3, from Bussey Institution, Aug. 5, gave
71 ♂♂—3, 3, 3, 3. 59 ♀♀—3, 3, 3, 3.
3 ♂♂—3, 3, a / bc, 3. 2 ♂♂—3, a / bc, 3, 3.
1 ♂ —3, a / bc, a / bc, 3. 1 ♀ —3, a / bc, 3, 3.
1 ♀ —3, 3, a / bc, 3.
♀—3, 3, 3, 3, from Bussey Institution, July, gave
32 ♂♂—3, 3, 3, 3. 32 ♀♀—3, 3, 3, 3.
3 ♀♀—/ abc, 3, 3, / abc.
1 ♀ —/ abc, / abc, 3, / abc.
1 ♀ —3, / abc, / a / bc, 3.
1 ♀ —/ abc, 3, 3, (*a*), 3.
1 ♀ —3, 3, / abc, 3. 1 ♂ —3, 3, ac, 3.
1 ♂ —/ abc, 3, 3, / abc. 1 ♂ —3, (*c*), 3, 3, 3.
1 ♂ —3, 3, 2, 3. 1 ♂ —3, 3, 3, / abc.

♀—3, 3, 3, 3, from Bussey Institution, July, gave

78 ♂♂—3, 3, 3, 3.	110 ♀♀—3, 3, 3, 3.
1 ♂ —3, 3, ab, 3.	1 ♂ —3, 2, ac, 3.
4 ♂♂—3, 2, 3, 3.	1 ♂ —3, 2, 2, 3.
1 ♂ —3, (*a*), 3, 3, 3.	1 ♂ —3, a / bc, a / bc, 3.
1 ♀ —3, 3, ac, 3.	1 ♀ —3, 3, 3, / abc.
1 ♀ —/ abc, 3, 3, / abc.	1 ♀ —/ abc, 3, 3, 3.
1 ♀ —3, a / bc, 3, 3.	

♀—3, 3, 3, 3, from Bussey, July, gave:*

30 ♂♂—3, 3, 3, 3.	34 ♀♀—3, 3, 3, 3.
1 ♂ —3, ac, 3, 3.	

2 ♀♀—3, 3, 3, 3, taken at Bussey Institution, gave:

191 ♂♂—3, 3, 3, 3.	203 ♀♀—3, 3, 3, 3.
2 ♂♂—3, ac, 3, 3.	3 ♂♂—3, 2, 3, 3.
2 ♂♂—3, 3, 2, 3.	1 ♂ —3, ab, 3, 3.
1 ♂ —3, 3, ac, 3.	1 ♀ —3, 2, 2, 3.
1 ♂ —3, ac, 2, 3.	

1 ♀—3, 3, 3, 3, from Bussey Institution, Nov. 20, gave:

124 ♂♂—3, 3, 3, 3.	118 ♀♀—3, 3, 3, 3.
1 ♀ —3, 3, 2, 3.	1 ♂—3, 2, 3, 3.
1 ♂ —3, ac, 3, 3.	

1 ♀ —3, 3, 3, 3, from Bussey Institution, Nov. 18, gave:

25 ♂♂—3, 3, 3, 3.	34 ♀♀—3, 3, 3, 3.
2 ♀♀—3, 3, ac, 3.	1 ♀—3, ac, 3, 3.
1 ♀ —3, a / bc, 3, 3.	1 ♂ —a / bc, 3, 3, 3.

1 ♀—3, 3, 3, 3, from scow, Boston, Aug. 8, gave:

17 ♂♂—3, 3, 3, 3.	19 ♀♀—3, 3, 3, 3.
1 ♀ —3, 3, a / bc, 3.	

Thus the progeny of normal ♀ ♀ (3, 3, 3, 3.) show considerable variation, and it is readily observed that this variation tends in some cases to reduction of bristles, in other cases to addition of bristles, while both tendencies may be observed in the same family. Taking the totals of these families we have normal ♂ ♂ 589, normal ♀ ♀ 410, variants by addition, 12 ♂ ♂ and 16 ♀ ♀; and variants by reduction, 21 ♂ ♂ and 6 ♀ ♀. This gives 2.6% variants by addition and 2.5% variants by reduction.

Let us now consider the families of *L. sericata* produced by mothers abnormal by reduction.

♂ and ♀—3, 3, 2, 3, taken at scow, Boston, Oct. 17, put in same box, gave:

13 ♂♂—3, 3, 3, 3.	8 ♀♀—3, 3, 3. 3.
1 ♂ —3, 3, 2, 3.	1 ♂ —3, ac, 3, 3.
1 ♂ —3, ac, ac, 3.	1 ♂ —3, 3, 2, 3.
2 ♀♀—3, 2, 3, 3.	

♀—3, 2, 3, 3, taken at scow, Boston, Aug. 8, gave:

32 ♂♂—3, 3, 3, 3.	22 ♀♀—3, 3, 3, 3.
1 ♂ —3, ac, 3, 3.	1 ♂ —3, 3, ac, 3.
1 ♂ —3, 3, ab, 3.	1 ♂ —3, 2, 3, 3.
1 ♂ —3, ac, 2, 3.	

*By reason of an imperfection in the technique at this point, this culture may have been contaminated from flies outside. The results are therefore, not averaged in with the total.

♀—3, 3, ac, 3, from scow, Boston, Aug. 8, gave 12 ♂♂—3, 3, 3, 3.
15 ♀♀—3, 3, 3, 3.
♀—3, ac, 2, 3, from Bussey Institution, July, gave:
18 ♂♂—3, 3, 3, 3. 8 ♀♀—3, 3, 3, 3.
♀—3, 2, 3, 3, from scow, Boston, Aug. 8, gave:
10 ♂♂—3, 3, 3, 3. 14 ♀♀—3, 3, 3, 3.
1 ♂ —3, 3, 2, 3. 1 ♂ —3, ac, 3, 3.
1 ♀ —3, ac, ac, 3.
♀—3, 2, 1, 3, from scow, Boston, Aug. 8, gave 10 ♂♂—3, 3, 3, 3. 12♀♀—3, 3, 3, 3. This family was continued into the third generation and will be considered below.
♀—3, ac, 3, 3, from scow, Boston, Aug. 8, gave:
7 ♂♂—3, 3, 3, 3. 7 ♀♀—3, 3, 3, 3.
1 ♀ —3, 3, a / bc, 3.

Taking the totals of these families of females deficient in bristles we find normal ♂♂102, normal ♀♀ 86, variants by reduction 10♂♂ and 4♀♀, variants by addition, 1♀. Thus from these rather small numbers we see the variants by reduction are 7%, while the variants by addition are 0.5%.

Let us consider now the progeny of females abnormal by addition of bristles.

♀—/ abc, 3, 3, / abc, from scow, Boston, Oct. 17, gave:
30 ♂♂—3, 3, 3, 3. 21 ♀♀—3, 3, 3, 3.
1 ♂ —3, (*a*), 3, 3, (*a*), 3.
♀—3, 3, 3, ab ! c, from scow, Boston, Oct. 17, gave:
9 ♂♂—3, 3, 3, 3. 20 ♀♀—3, 3, 3, 3.
1 ♂ —3, 3, 3, (*a*), 3. 1 ♂ —3, ac, 3, 3.
1 ♀ —3, ac, ac, 3.
♀—3, 3, a / bc, / abc, from scow, Boston, Aug. 8, gave:
40 ♂♂—3, 3, 3, 3. 32 ♀♀—3, 3, 3, 3.
3 ♂♂—3 a ! bc, 3, 3. 1 ♂—3, 3, a ! bc, 3.
1 ♂—3, (a), 3, 3, 3. 1 ♂ —3, ac, ac, 3.
1 ♀ —3, 3, a / b / c, 3. 2 ♀♀—3, a ! bc, 3, 3.
1 ♀ —3, 3, ac, 3. 1 ♀ —3, ab, 3, 3.
1 ♀ —3, 3, 2, 3. 1 ♀ —3, ac, 3, 3.
♀—a / bc, a / bc, 3, 3, from scow, Boston, Aug. 8, gave:
75 ♂♂—3, 3, 3, 3. 52 ♀♀—3, 3, 3, 3.
1 ♂ —3, 3, a / bc, 3. 1 ♂ —3 (*a*), 3, 3, 3.
1 ♂ —3, a / bc, 3, 3. 2 ♀♀—3, a / bc, 3, 3.
2 ♀♀—3, 3, a / bc, 3. 1 ♀ —3, 3, 3, a / bc.

Taking the totals of these families of females abnormal by addition of bristles we find normal ♂♂ 154, normal ♀♀ 125, variants by reduction, 2♂♂ and 5♀♀; variants by addition, 10♂♂ and 8 ♀♀. Thus the variants by reduction are 2.3% while the variants by addition are 6%.

From the averages of the reared stock we see there is a tendency to vary both toward reduction and toward addition of bristles and that this tendency is evidently of a hereditary character, the mean being shifted in the direction of the parental abnormality.

The female of *L. sericata* (3, 2, 1, 3.) taken at the garbage scow, Boston, August 8, gave as above recorded 10 ♂ ♂–3, 3, 3, 3, and 12 ♀ ♀–3, 3, 3, 3. Three pairs of these were segregated and gave offspring as follows:

1st pair gave:

10 ♂ ♂—3, 3, 3, 3.	7 ♀ ♀—3, 3, 3, 3.

2d pair gave:

42 ♂ ♂—3, 3, 3, 3.	39 ♀ ♀—3, 3, 3, 3.
1 ♂ —ac, 3, 3, ac.	2 ♂ ♂—3, ! abc, 3, 3.
1 ♂ —3, 2, 3, 3.	1 ♀ —3, ac, ac, 3.
1 ♀ —3, ac, 3, 3.	

3d pair gave:

55 ♂ ♂—3, 3, 3, 3.	62 ♀ ♀—3, 3, 3, 3.
7 ♂ ♂—3, 2, 2, 3.	1 ♀ —3, 2, 2, 3.
2 ♂ ♂—3, 3, 2, 3.	3 ♀ ♀—3, 2, 3, 3.
1 ♂ —3, 3, 3, ac.	1 ♀ —3, *a*bc, 3. 3.
1 ♂ —3, a ! bc, 3, 3.	1 ♀ —3, *a*bc, 2, 3.
1 ♀ —2, 3, 3, 3.	1 ♀ —3, 3, ac, 3.
1 ♀ —3, ab, 3, 3.	

Of the progeny of the first pair 1 ♂–3, 3, 3, 3, was mated to 2 ♀ ♀–3, 3, 3, 3, and produced offspring as follows:

163 ♂ ♂—3, 3, 3, 3.	170 ♀ ♀—3, 3, 3, 3.
2 ♂ ♂—3, ac, 3, 3.	2 ♀ ♀—3, ac, 3, 3.
2 ♂ ♂—3, 3, ac, 3.	1 ♀ —2, 3, 3, 3.
1 ♂ —3, 3, 2, 3.	1 ♀ —ac, 3, 3, 2.
1 ♂ —With very few scattered bristles.	1 ♀ —ac, 3, 2, 0.
	1 ♀ —ab, 3, ab, *b*c.
1 ♂ —3, a ! bc, 3, 3.	2 ♀ ♀—3, a ! bc, 3, 3.
1 ♂ —3, 3, a ! bc, 3.	2 ♀ ♀—3, 3, a ! bc, 3.
1 ♀ —3, 3, a ! bc, 3.	1 ♀ —*l* abc, 3, 3, *l* abc.
1 ♀ —a ! bc, 3, 3, 3.	

Of the progeny of the second pair 1 ♂–3, 3, 3, 3, was mated to 1 ♀–3, 3, 3, 3, and produced the following:

92 ♂ ♂—3, 3, 3, 3.	85 ♀ ♀—3, 3, 3, 3.
2 ♂ ♂—3, a! bc, a ! bc, 3.	5 ♂ ♂—3, a ! bc, 3, 3.
4 ♂ ♂—3, 3, a ! bc, 3.	3 ♀ ♀—3, a ! bc, 3, 3.
1 ♀ —3, 3, a *l* bc, 3.	1 ♀ —3, ac, 3, 3.

If we take the totals of this inbred stock we find them as follows:

362 ♂ ♂—3, 3, 3, 3.	363 ♀ ♀—3, 3, 3, 3.

By reduction, 18 ♂ ♂ and 18 ♀ ♀ or 5%.
By addition, 16 ♂ ♂ and 11 ♀ ♀ or 3.7%.

In the spring of 1912 a few specimens of *Calliphora vomitoria L.* and *C. viridescens* Desv. were taken at Cambridge and *C. erythrocephala* Meig was common all through the summer. In the fall *vomitoria* and *viridescens* appeared in considerable numbers in the vicinity of the Bussey Institution. The

records of chaetotaxy of the wild *Calliphorae* that was taken at Bussey are as follows. The bristles observed are the post-achrosticals and post-dorso-centrals as in *Lucilia*.

C. erythrocephala:

33 ♂♂—3, 3, 3, 3.	134 ♀♀—3, 3, 3, 3.
1 ♀ —3, 3, a ! bc, 3.	1 ♀ —2, 3, 3, 3.

C. vomitoria:

2 ♂♂—3, 3, 3, 3.	54 ♀♀—3, 3, 3, 3.

C. viridescens:

21 ♀♀—3, 3, 3, 3.	1 ♀ —3, ab, 3, 3.

These records show 3 abnormals out of 247, but the ratio is not very significant as the numbers are very small.

The records of breeding *Calliphorae* show rather interesting results.

A ♀ *erythrocephala*—3, 3, 3, 3, gave:

54 ♂♂—3, 3, 3, 3.	47 ♀♀—3, 3, 3, 3.
2 ♂♂—3, a ! bc, 3, 3.	

One of these abnormal males was mated to his sister and the pair gave the following offspring:

131 ♂♂—3. 3, 3, 3.	86 ♀♀—3, 3, 3, 3.
1 ♂ —3, (a), 3, 3, 3.	1 ♀ —3, a ! bc, aabc, 3.
4 ♂♂—3, a ! bc, 3, 3.	5 ♀♀—3, 3, a ! bc, 3.
1 ♂ —3, a ! bc, a ! bc, 3.	1 ♀ —3, 3, 3, ab.
8 ♂♂—3, 3, a ! bc, 3.	
1 ♂ —3, ab, 3, 3.	

Another wild ♀ *erythrocephala*—3, 3, 3, 3, gave:

80 ♂♂—3, 3, 3, 3.	74 ♀♀—3, 3, 3, 3.

Another wild ♀ *erythrocephala*—3, 3, 3, 3, gave:

97 ♂♂—3, 3, 3, 3.	97 ♀♀—3, 3, 3, 3.
	2 ♀♀—3, 3, ac, 3.

A ♀ *vomitoria*—3, 3, 3, 3, gave:

47 ♂♂—3, 3, 3, 3.	64 ♀♀—3, 3, 3, 3.
4 ♂♂—3, ac, 3, 3.	4 ♀♀—3, ac, 3, 3.
2 ♂♂—3, 3, ac, 3.	4 ♀♀—3, 3, ac, 3.
1 ♂ —3, 3, ab, 3.	1 ♀ —3, 2, 3, 3.
1 ♂ —3, 3, 2, 3.	

Another ♀ *vomitoria*—3, 3, 3, 3, gave:

32 ♂♂—3, 3, 3, 3.	64 ♀♀—3, 3, 3, 3.
1 ♂ —ab, 3, 3, 3,	2 ♂♂—3, a ! bc, 3. 3.
1 ♂ —3, 2, 3, 3.	1 ♀—3, / abc, / abc, 3.
1 ♂ —3, 2, 2, 3.	

A ♀ *viridescens*—3, 3, 3, 3, gave:

5 ♂♂—3, 3, 3, 3.	5 ♀♀—3, 3, 3, 3.
1 ♂ —3, 2, 3, 3.	1 ♀ —3, ac, 3, 3.

Another ♀ *viridescens*—3, ab, 3, 3, gave:

4 ♂♂—3, 3, 3, 3.	6 ♀♀—3, 3, 3, 3.
1 ♂ —3, ac, ac, 3.	

The totals of the bred stock for the three species are:

450 ♂♂—3, 3, 3, 3.	443 ♀♀—3, 3, 3, 3.

By reduction 14 ♂♂ and 4 ♀♀, or 2%; by addition 18 ♂♂ and 12 ♀♀ or 3%.

In the course of collecting Calliphoræ four specimens were obtained which I was unable to classify as belonging to any one of the three species common in Massachusetts. They appeared like inter-grades between *erythrocephala* and *viridescens*.

One small sized male had the beard black, the right cheek dark red, and the left cheek somewhat lighter in color. The right cheek was dark enough to place the specimen as viridescens but the left cheek resembled that of erythrocephala. One small and two large sized females answer also to the same description. In all four cases the right cheek is considerably darker then the left. The flies were examined by Mr. C. W. Johnson who was unable to classify them.

The meaning of these forms is uncertain and I should not feel justified in advancing an hypothesis without first performing breeding experiments with them.

SUMMARY AND CONCLUSIONS.

A number of meat flies of the Calliphorine genera, *Lucilia* and *Calliphora*, were collected during the summer and fall of 1912 and observations were made on the range of variation in the chaetotaxy. The bristles studied were the post-sutural achrosticals and dorso-centrals of the thorax. Breeding experiments were also performed in order to study the range of variation in the individual families.

Especial attention was given to *Lucilia sericata*. The following table gives the general results of the work on this species.

Wild Flies Captured	Normal 2,479		Abnormal by reduct'n Number 47		Percentage 2	Abnormal by addition Number 23		Percentage 1
	♂♂	♀♀	♂♂	♀♀		♂♂	♀♀	
Progeny of normal ♀♀	589	410	21	6	2.5	12	16	2.6
Progeny of ♀♀ abnormal by reduction	102	86	10	4	7	0	1	0.5
Progeny of ♀♀ abnormal by addition	154	125	2	5	2.3	10	8	6

As regards the wild flies captured it will be observed that there are twice as many abnormal by reduction as there are abnormal by addition. Too much importance should not be attached to this fact, as it may be due to an error. In a few cases there is reduction in the size of the bristle normally present, but as a general thing there is no reduction unless the bristle is entirely absent. On the other hand a very small bristle is frequently added and it is more rarely the case that a supernumerary bristle is of the full size. In looking over a large number of flies rapidly, one would then have a tendency to overlook the presence of the small additional bristle and to record more reduction than addition in number. As these flies were examined for the purpose of finding breeding material, careful attention was not given to this matter and I am inclined to consider the normal range of variation to be somewhat above two per cent both in the direction of reduction and in the direction of addition. This equality of variation in both directions is seen in the progeny of normal females. In the progeny of females abnormal by reduction and of females abnormal by addition, the variation of the offspring is seen to tend in the direction of the parental abnormality.

A single female lacking three bristles, (3, 2, 1, 3), gave ten males and twelve females of normal chaetotaxy. Three pairs of these gave 215 normal flies, 23 abnormal by reduction, and 3 abnormal by addition. A pair and a trio of these normals gave in the third generation from the original female, 510 normals, 13 abnormal by reduction, and 24 abnormal by addition. This shows regression away from the abnormal and suggests Galton's Law.

Observations made on *Lucilia sylvarum* and *caesar*, and on *Calliphora erythrocephala*, *viridescens*, and *vomitoria* lead me to believe that these five species are analogous to *Lucilia sericata* in the variation of their chaetotaxy.

In conclusion I wish to express my thanks for suggestions and criticism in the course of the work kindly offered by Professor Wheeler, Professor Castle and Mr. Brues.